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AIDS TO CONTENTMENT IN THE NAVY.

By REAR-ADMIRAL CASPAR F. GOODRICH, U. S. Navy.

Like the majority of my fellows, I have kept, more or less faithfully during the forty odd years of my service in the navy, a professional note book from which I may be tempted to draw, from time to time, for the benefit or warning or possibly for the amusement of my successors. I shall, naturally, omit such items as "By bending or splicing the topgallant clewlines into the topgallant sheets, time may be saved in crossing or sending down the topgallant yards, since the sheet and clewline can both be hooked or unhooked in one motion." These matters were once the very breath of life to us—now they are as extinct as the dodo. Let them rest in peace.

Many of my entries relate to the treatment of the enlisted man, and they counsel the widest liberality as tending to better discipline; so that recent discussions of the causes and remedies of desertion in the navy appeal to me with particular force, striking a very responsive chord.

I hope I need make no further apology for again raising my voice in favor of a broader practice, even if I incur the danger of telling "A Twice Told Tale." Nails are only driven home by repeated blows of the hammer.

The December number of the PROCEEDINGS OF THE NAVAL INSTITUTE contains an admirable article by Lieut. Ridley McLean, U. S. Navy, entitled "Permanence of Enlisted Force of the Navy," which deserves serious consideration for its temperate and sympathetic discussion of one of the most pressing subjects now engaging the attention of naval officers. The proof of its value, at least in my case, is that it has caused me to do some thinking on my own part, to recur to my old note books, and, as a result, to wonder whether the author did not feel compelled to skim somewhat lightly over the surface at certain spots, rather than to dig deep down among the roots, through a fear of assuming too radical an attitude in the eyes of the service. We all know how dreadful it is to be an iconoclast, how rough and stormy is the path of such as cast doubt upon the wisdom and excellence of the old ways or lapse from the cult of the ancients. No one can blame Lieutenant McLean if he has, as I suspect, stopped short at the gate of the temple, listening for the word of encouragement which might make him enter boldly and tear down the hoary idol from its seat.

Such reasons for conservatism can have less influence with me, for I need no longer apprehend the reproachful tone and the stern, yet would-be salutary, instruction of my seniors. A new query, therefore, rises in my mind, and it is whether what I am about to say is not largely what the author himself would have said had he enjoyed that freedom of speech which is one of the consolations of advancing years. This may be true and it may not be true. In any event, I do not mean to burden his younger shoulders with any of the responsibility for my remarks, even if they be prompted by what he has written and printed.

I.

Lieutenant McLean says, "I believe the features of the life (on board ship) which cause the greatest discontent are not necessary ones." Let us elaborate this text, expound it, and draw from our expounding the means to naval salvation.

That the statement is correct can hardly be denied, as all students of the subject appear to agree.

My own conviction is that the revolutionary changes which have swept over society during the past one hundred years have not been recognized in the navy, or, if perceived, have not been duly appreciated. The manner of regarding the enlisted per-

sonnel is substantially the same as it was at the close of the Civil War. Much improvement in their treatment has been effected by individual action in some rare cases, or by departmental ruling, but the general standpoint has remained unaltered. *En passant*, it may be remarked that the Department has generally been distinctly more advanced and more generous than the naval captain. The sailor is but too often looked upon as somehow lacking in the natural and healthy instincts of his fellow being in civil life. Throwing out of the reckoning the criminals who slip through the recruiting officer's fingers into the navy and who, by the way, lose little time in showing the cloven foot, it may be broadly stated that our enlisted men are good types of the American citizen. They come from respectable homes and worthy parents. Being of high intelligence, as a rule, they are more than willing to put up with all unavoidable adverse conditions. They do not ask to be molly-coddled, but they believe, with justice, that they should be treated as men. Ready to fulfil their side of the contract into which they entered on enlisting, they cannot understand why the party of the second part is so obstinate in refusing to fulfil his. Unable to force an execution of his obligation, they salve their conscience by the reflection that a broken contract releases all subscribers, and desert they do at the first convenient moment.

II.

This question, the change in the character of our ship's companies, lies at the very root of the matter. Let us, if we can, define this change in unmistakable terms.

Possibly, as good an illustration as any may be found in the composition of the crews of the flagship on the home station in the years 1880 and 1907. Through the courtesy of Lieutenant Commander H. B. Wilson I am able to make the following comparison by classes:

Class.	*Tennessee*, 1880.		*Maine*, 1907.	
	Number.	Per cent.	Number.	Per cent.
Seaman branch	272	81.2	334	49.9
Artificer branch	13	3.9	36	5.4
Engine room force	37	11	226	33.7
Special branch	4	1.2	34	5
Commissary branch	1	0.3	14	2
Messman branch	8	2.4	26	4
Total	335	100.0	670	100.0

This table brings out forcibly and indisputably the facts which, in a general way, have long been known to all.

The seaman, once four-fifths of the ship's company, is now a little less than half; the artificers and messmen have increased fifty per cent; the engineer's division has trebled in size; the clerical work has quadrupled;[1] the commissariat has sextupled, the greatest variation of all.

Yet even these figures, significant as they are, do not tell the whole story, for the "seaman" of to-day resembles the seaman of the eighties only in name. Both can steer, pull an oar, and use a marlin spike, but the former would be lost at the weather ear-ring in a gale of wind and the latter would spurn a monkey wrench as fit only for "greasers." Of the old-fashioned sailor, a few specimens still survive—and splendid, handy fellows they are too—but the breed is fast becoming extinct, so that the ratio of percentages between the seamen on the old *Tennessee* and those of the new *Maine,* really tells less than the truth.

From another point of view the two ship's companies, which I have cited as typical, are seen to differ *toto cælo.* On board the *Tennessee* was a large minority of foreigners, 45.3 per cent: on board the *Maine* the large majority is native born, 82.2 per cent. Thus we see that, whereas the *Tennessee's* crew was made up principally of sailors, foreign born, the *Maine's* is made up principally of native born Americans, of whom a large part are more or less skilled mechanics, whose titles and numbers suggest an industrial establishment—such as a big factory—rather than a man-of-war.

III.

Surely it can not be seriously urged that discipline and methods reasonably well suited to the *Tennessee* must, of necessity, avail with the *Maine;* that the treatment which yielded fairly good results when applied to the tarry-handed waif of the ocean in the wooden-ship era is, as a matter of course, adapted to the self-respecting American lad and the skilled mechanic whom we have tempted into the service by offers of high pay, rapid advancement, and a chance to see the world.

The fact is that the modern ship is a floating machine shop, and her inhabitants largely machinists. These must be treated, in a general way, as such men are treated on shore, if we would

[1] We write far too many letters.

have contentment among them. That is the price of peace and the longer we postpone the recognition of this fundamental principle, the worse it is for us.

It has been said with that approximation to complete truth which characterizes the epigram that a ship is merely a factory for producing hits per gun per minute, and that whatever militates against the quality or quantity of this output should be ruthlessly discarded. Granted, that so far as the enlisted man is concerned, this statement is correct, there are other aspects of a ships's life and functions which must not be neglected. She is a home, therefore she must be kept sweet, clean, and tidy. She is a hotel, therefore, her cooks and waiters must be capable and her food supplies carefully marketed. She is a unit in the fleet, therefore, her officers must know how to handle her in the battle so that her h. p. g. p. m. may be effectively placed. None the less, provided nothing essential is sacrificed, the quicker we deal with the enlisted man on the lines which the best organized industrial establishments have found by experience to be mutually profitable in dealing with his brother on shore, the better for the navy. Traditions and customs are excellent governors and fly wheels, but they should be abandoned whenever, ceasing to be useful, they become obstructive.

It should be an aim on board ship to compress all work into the hours between eight a. m. and, say, five p. m. Make them as busy as you please and pack them full of the keenest employment. Work is not a hardship, rather is it a normal existence, but when the day's labors are ended, lay down the tools, stop the exercises, shift into clean clothes, and devote the balance of the time to rest and pleasure.

There is, of course, the ship to be cared for and kept decent during the night and cleaned the next morning. For this purpose but a small fraction of the crew are really needed; one-quarter would be ample under ordinary circumstances. In fact, the more men there are ashore, the easier it is to freshen up the decks and compartments. There should be posted every day in port a list of men, not exceeding one in four, designated as "on duty." These are to remain on board and look out for the vessel; for the others there should be a free gangway until half past seven the next morning. If the latter preferred to remain on board they should be exempt from calls to duty. It would not be long before men acquired the habit of looking

upon the ship as their combined work shop and home. The knowledge that they could leave her whenever their services were not required would in itself breed a feeling of contentment, whose value in fighting efficiency it is hard to exaggerate; and, if combined with other features upon which I may touch later, would result, I am confident, in less shore-going, on the whole, than is now the practice. The irksome sense of restraint, of being kept on board against his will, when there is nothing for him to do, is the main source of evil under this head. I advise my fellow officers to read afresh what Mr. McLean has written on the subject, with every word of which I concur most fully. His italicized recommendations I repeat:

"Abolish deprivation of liberty as a punishment, except by sentence of a court martial; permit men to go ashore under much the same regulations as govern for officers, namely, when their services can be spared; and substitute as a regular form of punishment a uniform scale of fines based on percentage of pay; and to further prevent dissatisfaction let the money thus forfeited by fine be turned in to the general mess and used in subsisting the crew, or expended for the benefit of the crew in such manner as the commanding officer may direct."

IV.

But, I ask, why should we wait until Congress has been persuaded to enact a new scheme of punishment? Why can we not make a beginning at once, by practically admitting liberty on shore to be a man's right, and not a privilege to be granted or withheld at the whim of a cranky or dyspeptic captain? Are we naval officers so deficient in ingenuity that we can not devise some means within the law for punishing offenders without depriving them of leave?

The blessed day when fines shall be authorized, when a naval commander shall have the same power which is now confided to the merchant captain, may be long-a-coming. Until then, much water will flow under the bridge and many men will desert from the navy, or refuse to re-enlist, because they have only been allowed to "see Europe through a port hole," or because, as chief petty officers on the 1st conduct class, they have been denied permission to go ashore to their wives and children on the ground that the ship was not to be in that port more than twenty-four hours.

Imagine the state of mind of these worthy men forbidden

even to say good-bye to their families from whom the approaching cruise on the *U. S. S. Blanco* was to separate them for many weary months. No arguments as to the necessity of such action for the sake of "discipline" can avail with these luckless victims of an unwise abuse of power. *Ex pede Herculem.* We can all surmise how happy and efficient would be the crew of such a vessel.

Something can be done by broad-minded captains who are shrewd enough to see that peace of mind is a large factor in the fighting value of a ship, and they will, in following the lead of their reason, establish a standard by which smaller men will inevitably be judged. They will undoubtedly prove, beyond peradventure, the soundness of Mr. McLean's contentions, and thus furnish the grounds upon which the Department may base amendments to certain of its regulations regarding liberty.

V.

As a corollary to this proposition, the individual power to punish by deprivation of liberty must cease, excepting in so far that when a man overstays his leave his name may be put on the duty list for a number of hours proportional to the overstay (in a ratio to be fixed by the Department). Another man may go in his place, thus profiting by his shipmate's delinquency, and rejoicing accordingly.

Chronic leave-breakers should be discharged. We are too busy to bother with such cattle. Personally I have always felt and held that membership in the navy is an honor from which the undeserving should be excluded. If poor trash or the evil-disposed are retained against the real interest and high tone of the service, the desirable are loathe to enter or anxious to leave—a most unhappy state of affairs, yet one which in some cases is admitted to exist.

VI.

There is an ethical side to this question which is not neglected by the enlisted man, however much it is ignored by some officers. If he can truthfully say that, upon enlisting, he was clearly informed that his opportunities of going ashore would be at the will and pleasure of his captain, who could practically give or withhold as he liked, for any or no real reason, accountable in some instances to no immediate superior and only vaguely to a Navy Department which very properly can only act on

definite and authoritative statements by responsible persons, then he has no cause for complaint, but if nothing was said and the actual conditions on board ship not made abundantly plain, then his grievance is real and calls for the serious consideration of those in power.

VII.

Were the traditional "visitor from Mars," or even an intelligent and inquisitive layman, to go into the subject of the routine on board our ships, he would be impressed mainly by the large amount of sartorial preparation for the little work actually accomplished. It is stated, for example, that the men in the engineer's division have to shift their clothing no less than half a dozen times a day. (I have indeed heard the number fixed at eight, but this may have been an exaggeration.) In the words of the poet,

> "Now isn't this preposterous, now isn't this ridiculous?
> A thorough-paced absurdity; conceive it if you can."

It is high time to put a stop to such nonsense. A man returns from leave at 7.30 a. m. Let him put on his working clothes and keep them on till 5 p. m., when all hands wash up after the day's work, and put on their clean blue. They are then inspected before going to their supper or going ashore, as the case may be. The officers dress before their dinner. Why is not the practice sound for the enlisted man and his evening meal?

But I hear the chorus of protest chanting, "The service is going to the dogs," because there is no morning inspection! What is there especially sacred about a morning inspection? Is it not more logical to inspect *after* the labors of the day than *before?* I am tempted to use another officer's expressions in this connection. Lieut.-Commander C. P. Plunkett says very pertinently:

> "Practically for the last forty years either at 9.15 or 9.30 in the morning on board cruising ships the routine has called for quarters, muster, and inspection of the crew by the division officers, setting up exercises, and tests of certain mechanical appliances in the ship. This 'quarters' calls for every officer and man in the ship to go to certain stations, which stations in nine out of ten cases are not their battle stations; and there is nothing in any routine of any ship to my knowledge which calls for officers and men going to their battle stations oftener than once a week, the day set down for 'general quarters.'
>
> "There are a number of important tests, viz., electrical and mechanical

devices for loading and firing the guns, training the turrets, battle order instruments, ammunition hoists, etc., which are made by certain men detailed for this purpose, and no doubt this answers the requirements of the Regulations; but it is carried on in piecemeal, when as a matter of fact the tests which these men make would be made on the call for battle stations throughout the whole ship at the same time. The same holds true with regards to the engineer department of the vessel, and it is with reference to this particular point that I have to make the following suggestions:

"1st. That at 9.15 a. m. every day, except Saturdays and Sundays, the battle signal be sounded and every officer and man take his battle station. That all reports and instructions to officers and from them to the commanding officer be made by and through the devices which would be employed in time of battle.

"2d. That all mechanical devices throughout the ship, for whatever purpose, that would be used in time of battle be tested at this time by the men who are stationed to operate them in time of action, and that the divisional and battery officers observe and report the readiness of all the above mentioned devices, and any repairs or deficiencies which it may be necessary to make good.

"3d. That at this call all men cease all work of every kind, character, and description, and go to their battle stations immediately. This will avoid the numerous changes of uniform which are necessary to comply with the daily routine at this time of the day, when the men's clothing general appearance, etc., is closely examined by the division and battery officers. That the inspection of clothing, uniform, etc., be had daily at evening quarters, after the day's work has been completed, when every man is supposed to be washed and cleaned up, after a day of work which calls for his being out of the uniform which is prescribed for those whose ordinary duties do not require the wearing of dungarees or of blue and white working dress.

"4th. It is believed that in this way the battle drill, which is the supreme test of the efficiency of a modern battleship, will be given the prominence which it should have, in the eyes of every officer and man aboard ship; and it will be more readily responded to if a man feels that he can drop any work he may be engaged on and go to this drill, which is only of short duration, and return immediately upon the completion of it without having to shift uniform twice. It is also believed that both the ship's work and the battle drill will gain thereby; aside from the fact that no officer or man can plead excuse for his absence, nor will it be encouraged on account of other work.

"5th. It is intended that when 'cease firing' and 'secure' are sounded that the period drills and the ordinary routine proceed without intermission."

It is pleasing to find that I am not alone in my views.

The amount of time saved by this simple expedient would quickly show itself in the shorter tarryings at navy yards, for

many jobs, it is believed, could be effected on board ship which are now rendered impossible by the frequent changes of costume demanded by the routine.

In general terms, the uniform for the day should be dungarees; white or blue working clothes for boats' crews and others whose work is not of a nature to soil the clothing.

VIII.

The need and the organization of a home base for each of our fleets, where the ships shall remain when not engaged at target practice and from which they may start out every Monday for a week's cruising and tactical exercises, can only be referred to in this article. They will be treated at greater length at another time. The object is to secure more or less permanent *homes* for the enlisted men.

IX.

It has been suggested, as an expedient which has worked well in practice on board a certain torpedo destroyer, that an excellent form of punishment is in withholding some of a man's pay by "classing him." This is of the nature of a fine, while not taking actually from him that which is his. The gangway, in this case, is still free. I would like to hear from my brother officers on this point.

X.

A more uniform system of awarding punishment, if adopted, would remove some apparent discrepancies in the administration of discipline. An offence visited by two hours extra duty on board of one ship and by double irons on board of another would seem to depend for its gravity, not upon the essence of the act so much as upon the point of view of the commanding officer. A study on the latter's part of the precedents and the customs of other courts would do good and obviate the necessity of the regulating of this matter by an order from the Navy Department which, otherwise, is sure to come.

XI.

The whole body of enlisted men, would, in my opinion, heartily approve the sternest measures for punishing crime, just as they would regret any weak yielding to sentimentality in carrying out the sentences of competent courts. To suppose them

lacking in a high appreciation of the moral law is both unfair and unwarranted. The well-conducted among their number are unreservedly on the side of law and order. As to the bad,

> "No rogue e'er felt the halter draw
> With good opinion of the law."

Can it be true that the scamps write from our naval prisons to their friends afloat, "Come on, its a cinch?" Surely these places are not the attractive sea-side resorts their inmates are alleged to describe them to be.

XII.

In striking conformation of Lieutenant McLean's opinion, as quoted on page 906, are the allegations of a certain leading petty officer, a most worthy and reputable man, who commands my entire confidence. He believes that "it is the petty annoyances which drive men out of the service." When asked, "What are your petty annoyances?" he answers, "Liberty, money, and punishments."

It is under these three heads that improvement must be sought in the enlisted man's condition. Each, in turn, seems the most important. If we can ever bring ourselves to a realization that liberty is a right, not a privilege; that a man's money is his own; and that punishments should be uniform throughout the fleet, I think we should see fewer desertions and more re-enlistments.

The same petty officer thought a needless drill, or a needlessly frequent repetition of some drills tended to discourage. Said he: "No man ever squeals over gun drill; but men hate the thought of fire and collision drills" (meaning too many of them) "and above all, bag inspection every week. They do not mind on account of the work, but because they feel it is so much waste time." And then he went on to say: "The men despised all drills and all work not tending to battle efficiency." While, of course, Jack's view is but limited, still is it not a fine thing that he should so highly value the things that are really essential?

XIII.

It may be fairly asked why keep harping upon this string; why not say something new and fresh? To this criticism I can only reply that the case is serious beyond all exaggeration, that

iteration and reiteration must be expected from many quarters and to continue until needless, and, in some instances, intolerable abuses come to an end. There is nothing novel in what I have said. I should have been glad had some other pen than mine been employed in calling attention again to this subject, but, in discussing some aspects of our personnel, I could not pass over in silence features of our life afloat which cause me and all true lovers of our service the gravest solicitude.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

PERMANENT COMPANY ORGANIZATION FOR THE UNITED STATES MARINE CORPS.

By CAPTAIN H. L. ROOSEVELT, Assistant Quartermaster, U. S. M. C.

It is a generally recognized fact among officers of the Marine Corps, that a permanent company organization would be of the greatest benefit to the Corps, and is even considered by a number to be an absolute necessity.

The question may be considered, therefore, as having resolved itself not into "Would a permanent company organization be of advantage to the Marine Corps?" but "How can such an organization be brought about, taking into consideration the fact that so many detachments on board ship are considerably less in number than the strength of a normal company would be?"

I will first endeavor to show how the permanent companies could be organized, and the effect of such organization on the Corps as a whole, and then show wherein it would be of benefit.

There are now allowed by law the following company officers and enlisted men:

Captains	72
1st lieutenants	85
2d lieutenants	72
Enlisted men	8771

This number of enlisted men includes six sergeant majors and sixty quartermaster sergeants who would not be assigned to companies, leaving a total enlisted strength for such assignment of 8699.

The formation of each company should be as follows:

Captain	1
1st lieutenant	1
2d lieutenant	1
1st or gunnery sergeant	1
Sergeants	3
Corporals	12
Drummer	1
Trumpeter	1
Privates	84
Total	105

With the total allowed strength of 8699 enlisted men available, 85 companies could be organized, leaving a remainder of 29. As we can never count on the Corps being recruited up to its full strength of men turned over for duty, it would not be advisable to form so many companies, 80 being about all that could be kept reasonably full. This would then leave a total of about 539 men unassigned.

In order to keep these companies up to their required strengths with the least possible confusion there would have to be established three general rendezvous to which all recruits, enlisted at the various recruiting stations throughout the United States, should be sent, two on the Atlantic and one on the Pacific coast. The natural places for these rendezvous are the Marine Barracks, New York, and the Marine Barracks, Norfolk, in the East, and the Marine Barracks, Mare Island, in the West. All men should be sent to these posts from the recruiting districts and should be kept there until sufficiently conversant with their duties as soldiers, to be turned over to one of the companies.

The commanding officer of each company should know from which barracks recruits, to fill vacancies, would be sent, and the commanding officers of these barracks should be furnished with lists of the full strengths at which these companies are to be kept, and they should have a general order to keep the companies at their authorized strengths, transferring the men as soon as they become available, without waiting for a specific order in each case from headquarters; but reporting to headquarters as each transfer is made.

Each permanent barracks should be designated as a one, two,

three, or four company post. The following is offered as a suggestion as to how these posts could be apportioned:

Portsmouth, N. H.	1	Company
Boston, Mass.	3	"
Newport, R. I.	1	"
New York, N. Y.	4	"
League Island, Pa.	3	"
Annapolis, Md.	3	"
Washington, D. C.	3	"
Navy Yard, Washington, D. C.	1	"
Norfolk, Va.	4	"
Port Royal, S. C.	1	"
Charleston, S. C.	1	"
Key West, Fla.	1	"
Pensacola, Fla.	1	"
New Orleans, La.	1	"
Mare Island, Cal.	4	"
Naval Training Station, San Francisco, Cal.	1	"
Bremerton, Wash.	1	"
Total	34	Companies.

Permanent foreign stations:

Honolulu	1	Company
Olongapo	12	"
Cavite	3	"
Polloc	1	"
Sitka	1	"
Guantanamo	1	"
Culebra	1	"
San Juan	1	"
Guam	1	"
Panama	2	"
Pekin	1	"
Midway		(a det'mt)
Total, foreign	25	Companies
For sea duty on twenty-one battleships and armored cruisers	21	Companies
Grand total	80	Companies

It will be seen that in order to organize 80 companies there is at present a shortage of 8 captains and 8 second-lieutenants. Relief in this respect should be sought through Congress at once, but until this is procured the eight senior first-lieutenants could be detailed to command companies.

Now we will suppose that these eighty companies have been organized and are stationed, as suggested above, at the barracks at home and abroad, what are we going to do about the ships? This seems to be very easily answered. We have provided for twenty-one full companies of 102 enlisted men each for sea service. This means a total of 2142, which is 44 more than were at sea at the date of the last annual report of the Brigadier-General, Commandant, Oct. 1, 1906; all too few, but undoubtedly all that could be spared with the limited number of men and the almost unlimited duties which we are called upon to perform.

There were in commission on January 1, 1907, nineteen (19) ships whose marine detachments were commanded by captains; as these detachments average about sixty-six men each, this makes a total of 1254 enlisted men, leaving 1092 men to be divided among the other ships carrying marine detachments. These nineteen detachments could be regularly organized companies, as a number of companies will, in the natural course of events, through expiration of enlistments, desertions, sentences of general court-martial, and deaths, become reduced to about sixty-six men before they have been organized a great length of time.

Now we will suppose that a battleship just about to go into commission needs a marine detachment. Upon examining the roster, which would be kept at headquarters, it would be found that the 15th company, let us say, was due for sea. It would probably be known some months in advance when this company would be needed for this duty, so the vacancies occurring therein would not be filled in order that the enlisted strength might be allowed to fall off to say 85 men. Only seventy, however, would be needed. In this case what would be easier than to transfer 15 of the least desirable men to either New York, Norfolk, or Mare Island, to be re-assigned from these posts to vacancies in other companies? The first lieutenant of the company would also be detached and ordered to either New York, Norfolk, or Mare Island for duty until his services were needed at sea, as a post or battalion adjutant, or quartermaster, recruiting duty, or for other detached service.

There are now two companies not provided for. These could be sent to receiving ships such as the *Franklin* or *Southery* for permanent station, or could be held in reserve for such duty as they might be called upon to perform.

There now remain several ships which carry small detachments in command of lieutenants and non-commissioned officers. Among this class are the average receiving ships at navy yards. The detachments on these ships could be taken from one of the companies at the barracks of the yard at which the receiving ship is permanently stationed, and could be carried on the records as part of such companies, but on *detached service*. They of course would be absolutely independent of such companies, but for drills ashore at the barracks would join the companies to which they originally belonged, and when relieved from duty on the receiving ship, would rejoin their proper organizations.

The small detachments on sea-going ships commanded by lieutenants and non-commissioned officers would have to be considered as separate unorganized detachments, and when their tour of the sea duty had expired they could be ordered ashore at either New York, Norfolk, or Mare Island, to be later absorbed in some of the permanent companies.

One of the main advantages of this scheme of organization is that it would require no legislation to carry it into effect, as it could be put into force by executive or department order.

Following are some of the benefits which would be derived from such an organization by which the efficiency of the corps would be incalculably increased, namely:

(1) Increased efficiency through having a body of men continually together, and serving under the same officers and non-commissioned officers year in and year out.

(2) Ease of mobilization into expeditionary forces of battalions, regiments, or brigades.

(3) Greater facility in handling staff returns and papers of all descriptions, and the increased familiarity that all officers would obtain therewith.

In regard to the first advantage mentioned above: All officers of the marine corps who have had experience both with permanently organized companies outside the continental limits of the United States (as our foreign stations are the only ones at which we have permanent company organization with the exception of the small posts at home), generally agree that far better results have been obtained as far as efficiency is concerned when companies remain with the same officers and men for a considerable length of time. First rate discipline can not be

maintained unless the captain of his company knows the name and as many of the characteristics as possible of every man in his company, and this is impossible when the whole complement are continually shifting; nor will there be any satisfaction among the non-commissioned officers and other enlisted men, or the officers either, when there are these constant shifts. There will always be evident the spirit of unrest and the idea that everything connected with the marine corps is of a temporary character, and none of that feeling of a certain amount of permanency which is essential to contentment among all hands.

Taking up the next two features, those of mobilization into expeditionary forces, and improved system of handling "staff returns." From my personal experience at headquarters of the Marine Corps in Washington and in the field I have seen at close range the great fault of our present system due to lack of permanent organization.

During the year 1906, within a period of five months, I was on duty at headquarters when two expeditions were being organized and I joined these same organizations and went into the field with them. The first one was a battalion, organized in May, 1906, for service in Panama, and the second was organized in September of the same year for Cuban service. I have no criticisms to make in regard to the promptness and dispatch with which these expeditions were organized and embarked for tropical field service, as it reflected great credit on all concerned, considering the fact that there was absolutely no organization as a foundation to start with, but I do not hesitate to criticise a system which is responsible for so much needless confusion and delay.

In order that I may make myself clear I will give an illustration of the manner in which a battalion is mobilized and organized for foreign service. For example, let us suppose that the Commandant of the Marine Corps has received word from the Secretary of the Navy that he wants about four hundred marines to be able to sail from League Island within forty-eight hours. Headquarters immediately gets busy and the wires are soon hot. The Commandant's assistants begin overhauling the rosters to find the necessary number of available officers. As the four hundred men will be organized into a battalion of four companies, it means that there will have to be selected one major, four captains, five or six first lieutenants, and four second lieutenants. Various things must be considered in selecting these

officers, such as the length of time since their last tours of sea or foreign service were ended, their proximity to the place of mobilization, the number of officers which would be left at the various posts in the event of certain ones being detached, etc. All this takes considerable time and a certain amount of confusion is bound to be caused. The Adjutant and Inspector's office must select the number of men by rank from each post to join this expedition, having due regard to the number to be left at the posts, and keeping in view the number of each grade necessary to make up the proper battalion organization.

The Quartermaster's office must arrange for the proper transportation of troops from all of the important posts on the Atlantic coast, as such a selection usually takes in men from Portsmouth, N. H., to Norfolk, Va., to the point of embarkation, so that they shall arrive at the proper time; this means an infinite amount of work and the closest attention must be paid to details. This department must also arrange for the proper equipping of these troops and see that all the necessary supplies, stores, etc., are placed aboard the ship detailed to transport them.

The Paymaster's office also has its troubles to see that all the pay accounts pertaining to the men are properly handled and transferred.

Now let us suppose that the officers and men have finally been selected, the transportation arrangements completed, and the necessary orders given for their concentration at League Island. There is bound to be endless confusion and an unnecessary amount of work at the posts from which these men are detached, owing to the fact that for each man the necessary markings and the usual entries must be made in the descriptive book and signed by the commanding officers, transfer clothing accounts, and transfer pay accounts must be made out, and a thousand and one little details attended to. The detachments, however, finally reach League Island where the various commanders of same report to the commanding officer of the expeditionary battalion. This officer has already been furnished with a list showing the names of the officers who have been selected for this duty and the number of men with the posts from which they have been ordered, and he has arranged on paper the company and battalion organizations. As each detachment arrives, therefore, the officers and men are assigned to the companies for which they have been

designated, and upon the arrival of the last detachment the battalion is formed and taken aboard ship.

The chances are that the major in command knows the names of about half of his officers, the captains are lucky if they have ever seen their lieutenants before, and they probably don't know the names of, and have never seen, ten per cent of their commands, including their first sergeants.

The ship, however, finally gets under way and then the straightening out process begins; descriptive lists are sorted out and distributed among the company commanders, lists of their companies are furnished them, receipts are taken by the quartermaster for all government property actually in the hands of the companies, etc., so that by the time that the battalion has been together for about a week the company commanders may possibly know the names of their non-commissioned officers, if they are good at remembering names, and about one-half of the men may know their officers by sight.

Now let us imagine ourselves confronted by the same orders, but with a permanent company organization: The roster kept at headquarters is consulted and it is found that the 3d, 17th, 22d, and 73d companies are due and available for such service, and companies, as they near the top of the roster for foreign or sea service, should be transferred to the larger posts so that they may be moved at a minute's notice without seriously affecting the post. Let us suppose that these companies are at Boston, New York, League Island, and Washington. Telegraphic orders are sent out from headquarters directing these companies to proceed immediately to the point of centralization; a major and two first lieutenants are ordered as commanding officer, battalion adjutant, and battalion quartermaster, respectively. The Quartermaster of the Corps is directed to arrange transportation for these four companies, which is readily done, as the exact strength of each company is known at headquarters.

There is no confusion at the posts from which these companies are detached, due to the handling of descriptive books and transfer clothing and pay accounts, as these records are all kept by the company commanders, and all they have to do is to pack their papers in field desks and move out.

There is no confusion at the point of mobilization, as each company commander has his men under absolute control, knowing as he does every one of them by name.

When finally embarked on board ship everything runs smoothly, as the records of each company are intact and the battalion records have been very much simplified and are much less cumbersome, and easier to handle than was formerly the case. As the company commanders would habitually be required to make returns for all property, such as arms, etc., actually in use by their companies, to the quartermaster of the organization or post to which they belonged and to submit clothing account rolls to the same officer, the quartermaster's accounts would be very simple to handle and cause very little trouble.

The same would be true in regard to papers relating to the pay department, as there would be no necessity of making out transfer pay accounts.

I think that all officers in any way connected with the Cuban expedition will realize what it would have meant if such a system had been in operation when we came to Cuba, as the hardest work done by all of us has been the straightening out of clothing accounts, due mainly to the fact that they did not accompany the men, and that a great many of these men were transferred back to the United States before these accounts finally reached Cuba; also to the fact that most of the company commanders were unfamiliar with these papers, and that the provisions of the system of accountability are inapplicable to the conditions under which we were serving at first.

I have gone into the question of expeditionary forces rather deeply, as it is these which must be considered primarily in connection with any change in Marine Corps organization, as our manner of performing such duties determines largely our degree of efficiency, but I desire to impress upon all who may read this, the absolute necessity for some betterment of the conditions which prevail at present and which are almost unbearable to those of us who have been confronted with them, not only on expeditionary work, but at the regular home posts, and at the same time to demonstrate how easily all the graver faults may be remedied.

What I have said in regard to company organization for purposes of mobilization is equally applicable to marines serving at marine barracks in the United States, and as a means of education alone, for company officers in the handling of all paper work, etc., is well worthy of consideration.

I personally have served at posts and stations where the

marines have been permanently organized into companies, and at those where no organization was in effect, and there has been no comparison in the efficiency, appearance, and contentment of the troops.

With such an easy method of solution of this troublesome problem at hand, which does not require any legislation whatever, why is it that the organization of the Marine Corps to-day, with 278 officers and 8771 enlisted men is exactly the same as it was years ago when the strength of the Corps was one-seventh of what it is now, and when our duties have increased ten fold in importance, and our field of action has been correspondingly enlarged?

I hope that this paper will at least have the effect of starting a discussion among officers which may eventually lead to an improvement in the present conditions.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

A LETTER FROM BENJAMIN FRANKLIN, TO DR. BROWNRIGG, RELATIVE TO THE USE OF OIL FOR STILLING THE WAVES.

(Reprinted from the *Annual Register*, Vol. 18, 1775.[1])

LONDON, Nov. 7, 1773.

DEAR SIR: I thank you for the remarks of your learned friend at Carlisle. I had, when a youth, read and smiled at Pliny's account of a practice among the seamen of his time, to still the waves in a storm by pouring oil into the sea; which he mentions, as well as the use made of oil by the divers; but the stilling a tempest by throwing vinegar into the air had escaped me. I think with your friend, that it has been of late too much the mode to slight the learning of the ancients. The learned, too, are apt to slight too much the knowledge of the vulgar. The cooling by evaporation was long an instance of the latter. This art of smoothing the waves with oil is an instance of both.

Perhaps you may not dislike to have an account of all I have heard and learned, and done in this way. Take it, if you please, as follows:

In 1757, being at sea in a fleet of 96 sail, bound against Louisburg, I observed the wakes of two of the ships to be remarkably smooth, while all the others were ruffled by the wind, which blew fresh. Being puzzled with the differing appearance, I at last pointed it out to our captain, and asked him the meaning of it. "The cooks" says he "have, I suppose, been just emptying their greasy water through the scuppers, which has greased the sides of those ships a little"; and this answer he gave me

[1] This letter is interesting as showing that the modern use of oil for moderating the effects of the sea is but a revival of an ancient practice; its particular value, however, is as illustrating the workings of Franklin's mind when grappling with a new and somewhat mysterious problem. —P. R. A.

with an air of some little contempt, as to a person ignorant of what everybody else knew. In my own mind I at first slighted his solution, though I was not able to think of another; but, recollecting what I had formerly read in Pliny, I resolved to make some experiment of the effect of oil on water, when I should have the opportunity.

Afterwards being again at sea in 1762, I first observed the wonderful quietness of oil on agitated water, in the swinging glass lamp I made to hang up in the cabin, as described in my printed papers, page 438 of the fourth edition. This I was continually looking at and considering, as an appearance to me inexplicable. An old sea captain, then a passenger with me, thought little of it, supposing it an effect of the same kind with that of oil put on water to smooth it, which he said was a practice of the Bermudians when they would strike fish, which they could not see, if the surface of the water was ruffled by the wind. This practice I had never before heard of, and was obliged to him for the information; though I thought him mistaken as to the sameness of the experiment, the operations being different, as well as the effects. In one case, the water is smooth till the oil is put on, and then becomes agitated. In the other it is agitated before the oil is applied, and then becomes smooth. The same gentleman told me he had heard it was a practice with the fishermen of Lisbon, when about to return into the River, (if they saw before them too great a surf upon the bar, which they apprehended might fill their boats in passing) to empty a bottle or two of oil into the sea, which would suppress the breakers, and allow them to pass safely; a confirmation of this I have not since had an opportunity of obtaining; but discoursing of it with another person, who had often been in the Mediterranean, I was informed that the divers there, who, when under the water in their business, need light, which the curling of the surface interrupts by the refractions of so many little waves, let a small quantity of oil now and then out of their mouths, which rising to the surface smooths it, and permits the light to come down to them. All these informations I at times revolved in my mind, and wondered to find no mention of them in our books of experimental philosophy.

At length being at Clapham, where there is on the common a large pond, which I observed to be one day very rough with the wind, I fetched out a cruet of oil, and dropt a little of it on

the water. I saw it spread itself with surprising swiftness upon the surface; but the effect of smoothing the waves was not produced; for I had applied it first on the leeward side of the pond, where the waves were largest, and the wind drove my oil back upon the shore. I then went to the windward side, where they began to form; and there the oil, though not more than a teaspoonful, produced an instant calm over a space several yards square, which spread amazingly, and extended itself gradually till it reached the leeward side, making all that quarter of the pond, perhaps half an acre, as smooth as a looking-glass.

After this, I contrived to take with me, whenever I went into the country, a little oil in the upper hollow joint of my bamboo cane, with which I might repeat the experiment as opportunity should offer; and I found it constantly to succeed.

In these experiments, one circumstance struck me with particular surprise. This was the sudden, wide, and forcible spreading of a drop of oil on the face of the water, which I do not know that anybody has hitherto considered. If a drop of oil is put on a polished marble table, or on a looking-glass that lies horizontally, the drop remains in its place, spreading very little. But, when put on water, is spreads instantly many feet round, becoming so thin as to produce the prismatic colors for a considerable space, and beyond them so much thinner as to be invisible, except in its effect of smoothing the waves at a much greater distance. It seems as if a mutual repulsion between its particles took place as soon as it touched the water, and a repulsion so strong as to act on other bodies swimming on the surface, as straws, leaves, chips, &c, forcing them to recede every way from the drop, as from a center, leaving a large clear space. The quantity of this force, and the distance to which it will operate, I have not yet ascertained; but I think it a curious inquiry, and I wish to understand whence it arises.

In our journey to the north, when we had the pleasure of seeing you at Ormathwaite, we visited the celebrated Mr. Smeaton, near Leeds. Being about to show him the smoothing experiment on a little pond near by his house, an ingenious pupil of his, Mr. Jessop, then present, told us of an odd appearance on that pond, which had lately occurred to him. He was about to clean a little cup in which he kept oil, and he threw upon the water some flies that had been drowned in the oil. These flies presently began to move, and turned around on the water very rapidly, as

if they were vigorously alive, though on examination he found they were not so. I immediately concluded that the motion was occasioned by the power of the repulsion above mentioned, and that the oil issuing gradually from the spongy body of the fly continued the motion. He found some more flies drowned in oil, with which the experiment was repeated before us. To show that it was not any effect of life recovered by the flies, I imitated it by little bits of oiled chips and paper cut in the form of a comma, of the size of a common fly; when the stream of repelling particles issuing from the point made the comma turn around the contrary way. This is not a chamber experiment; for it cannot well be repeated in a bowl or dish of water on a table. A considerable surface of water is necessary to give room for the expansion of a small quantity of oil. In a dish of water, if the smallest drop of oil be let fall in the middle, the whole surface is presently covered with a thin greasy film proceeding from the drop; but as soon as that film has reached the sides of the dish, no more will issue from the drop, but it remains in the form of oil, the sides of the dish putting a stop to its dissipation by prohibiting the further expansion of the film.

Our friend, Sir John Pringle, being soon after in Scotland, learnt there that those employed in the herring fishery, could at a distance see where the shoals of herrings were by the smoothness of the water over them, which might possibly be occasioned, he thought, by some oiliness proceeding from their bodies.

A gentleman from Rhode Island told me, it had been remarked that the harbor of Newport was ever smooth while any whaling-vessels were in it; which probably arose from hence, that the blubber which they sometimes bring loose in the hold, or the leakage of their barrels, might afford some oil to mix with that water, which from time to time they pump out to keep the vessel free; and that same oil might spread over the surface of the water in the harbor, and prevent the forming of any waves.

This prevention I would thus endeavor to explain.

There seems to be no natural repulsion between water and air, such as to keep them from coming into contact with each other. Hence we find a quantity of air in water; and, if we extract it by means of the air pump, the same water again exposed to the air will soon imbibe an equal quantity.

Therefore air in motion, which is wind, in passing over the

smooth surface of water, may rub, as it were, upon that surface, and raise it into wrinkles, which, if the wind continues, are the elements of future waves.

The smallest wave once raised does not immediately subside, and leave the neighboring water quiet; but in subsiding raises nearly as much of the water next to it, the friction of the parts making little difference. Thus a stone dropt in a pool raises first a single wave round itself; and leaves it, by sinking to the bottom; but that first wave subsiding raises a second, the second a third, and so on in circles to a great extent.

A small power continually operating will produce a great action. A finger applied to a weighty suspended bell can at first move it but little; if repeatedly applied, though with no greater strength, the motion increases, till the bell swings to its utmost height, and with a force that cannot be resisted by the whole strength of the arm and body. Thus the small first-raised waves, being continually acted upon by the wind, are, though the wind does not increase in strength, continually increased in magnitude, rising higher and extending their bases, so as to include a vast mass of water in each wave, which in its motion acts with great violence.

But if there be a mutual repulsion between the particles of oil, and no attraction between oil and water, oil dropt on water will not be held together by adhesion to the spot whereon it falls; it will not be imbibed by the water; it will be at liberty to expand itself; and it will spread on a surface that, besides being smooth to the most perfect degree of polish, prevents, perhaps by repelling the oil, all immediate contact, keeping it at a minute distance from itself; and the expansion will continue, till the mutual repulsion between the particles of oil is weakened and reduced to nothing by their distance.

Now I imagine, that the wind, blowing over water thus covered with a film of oil, cannot easily catch upon it, so as to raise the first wrinkles, but slides over it, and leaves it smooth as it finds it. It moves a little the oil indeed, which, being between it and the water, serves it to slide with, and prevents friction, as oil does between those parts of a machine that would otherwise rub hard together. Hence the oil dropt on the windward side of a pond proceeds gradually to leeward, as may be seen by the smoothness it carries with it, quite to the opposite side. For the wind, being thus prevented from raising the first wrinkles that

I call elements of waves, cannot produce waves, which are to be made by continually acting upon and enlarging those elements, and thus the whole pond is calmed.

Totally therefore we might suppress the waves in any required place, if we could come at the windward place where they take their rise. This in the ocean can seldom, if ever, be done. But perhaps something may be done on particular occasions, to moderate the violence of the waves, when we are in the midst of them, and prevent their breaking, where that would be inconvenient.

For, when the wind blows fresh, there are continually rising on the back of every great wave a number of small ones, which roughen its surface, and give the wind hold, as it were, to push it with greater force. This hold is diminished by preventing the generation of those small ones. And possibly too, when a wave's surface is oiled, the wind, in passing over it, may rather in some degree press it down, and contribute to prevent its rising again, instead of promoting it.

This as mere conjecture would have little weight, if the apparent effects of pouring oil in the midst of waves were not considerable, and as yet not otherwise accounted for.

When the wind blows so fresh, as that the waves are not sufficiently quick in obeying its impulse, their tops being thinner and lighter are pushed forward, broken, and turned over in a white foam. Common waves lift a vessel, without entering it; but these when large sometimes break above and pour over it, doing great damage.

That this effect might in any degree be prevented, or the height and violence of waves in the sea moderated, we had no certain account; Pliny's authority for the practice of seamen in his time being slighted. But discoursing lately on this subject with his excellency Count Bentinck of Holland, his son the honourable Captain Bentinck, and the learned Professor Allemand, (to all whom I showed the experiment of smoothing in a windy day the large piece of water at the head of the Green Park;) a letter was mentioned which had been received by the Count from Batavia, relative to the saving of a Dutch ship in a storm by pouring oil into the sea. I much desired to see that letter, and a copy of it was promised me, which I afterwards received.

EXTRACT OF A LETTER FROM MR. TENGNAGEL TO COUNT BENTINCK, DATED AT BATAVIA THE 15TH OF JANUARY, 1770.

"Near the islands Paul and Amsterdam, we met with a storm, which had nothing particular in it worthy of being communicated to you, except that the captain found himself obliged, for greater safety in wearing the ship, to pour oil into the sea, to prevent the waves breaking over her, which had an excellent effect, and succeeded in preserving us. As he poured out but a little at a time, the East India Company owes perhaps its ship to only six demiaumes of oil-olive. I was present upon deck when this was done; and I should not have mentioned this circumstance to you, but that we have found people here so prejudiced against the experiment as to make it necessary for the officers on board and myself to give a certificate of the truth on this head, of which we made no difficulty."

On this occasion, I mentioned to Captain Bentinck a thought which had occurred to me in reading the voyages of our late circumnavigators, particularly where accounts are given of pleasant and fertile islands which they much desired to land upon, when sickness made it more necessary, but could not effect a landing through a violent surf breaking on the shore, which rendered it impracticable. My idea was, that possibly by sailing to and fro at some distance from such lee shore, continually pouring oil into the sea, the waves might be so much depressed and lessened before they reached the shore as to abate the height and violence of the surf, and permit a landing; which, in such circumstances, was a point of sufficient importance to justify the espense of the oil that might be required for the purpose. That gentleman, who is ever ready to promote what may be of public utility, though his own ingenious inventions have not always met with the countenance they merited, was so obliging as to invite me to Portsmouth, where an opportunity would probably offer, in the course of a few days, of making the experiment on some of the shores about Spithead, in which he kindly proposed to accompany me, and to give assistance with such boats as might be necessary. Accordingly, about the middle of October last, I went with some friends to Portsmouth; and a day of wind happening, which made a lee shore between Haslar Hospital and the point near Jillkecker, we went from the Centaur with the long-boat and barge towards that shore. Our disposition was this; the long-boat was anchored about a quarter of a mile from the shore; part of the company were landed behind the point (a place more sheltered from the sea) who came round

and placed themselves opposite to the long-boat, where they might observe the surf, and note if any change occurred in it, upon using the oil. Another party in the barge, plied to windward of the long-boat, as far from her as she was from the shore, making trips of about half a mile each, pouring oil continually out of a large stone bottle, through a hole in the cork, somewhat bigger than a goose-quill. The experiment had not, in the main point, the success we wished, for no material difference was observed in the height or force of the surf upon the shore; but those who were in the long-boat could observe a tract of smoothed water, the whole length of the distance in which the barge poured the oil, and gradually spreading in breadth towards the long-boat. I call it smoothed, not that it was laid level, but because, though the swell continued, its surface was not roughened by the wrinkles, or smaller waves, before mentioned; and none, or very few white caps (or waves whose tops turn over in foam) appeared in that whole space, though to windward and leeward of it there were plenty; and a wherry, that came round the point under sail, in her way to Portsmouth, seemed to turn into that tract of choice, and to use it from end to end, as a piece of turn-pike road.

It may be of use to relate the circumstance even of an experiment that does not succeed, since they may give hints of amendment in future trials; it is therefore I have been thus particular. I shall only add what I apprehend may have been the reason of our disappointment.

I conceive that the operation of oil on water is, first, to prevent the raising of new waves by the wind; and, secondly, to prevent its pushing those before raised with such force, and consequently their continuance of the same repeated height, as they would have done if their surface were not oiled. But oil will not prevent waves being raised by another power, by a stone, for instance, falling into a still pool; for they then rise by the mechanical impulse of the stone, which the greasiness of the surrounding water cannot lessen or prevent, as it can prevent the wind's catching the surface and raising it into waves. Now waves once raised, whether by the wind or any other power, have the same mechanical operation, by which they continue to rise and fall, as a pendulum will continue to swing a long time after the force ceases to act by which the motion was first produced; that motion will, however, cease in time;

but time is necessary. Therefore, though oil, spread on an agitated sea, may weaken the push of the wind on those waves whose surfaces are covered by it, and so, by receiving less fresh impulse, they may gradually subside; yet a considerable time, or a distance through which they will take time to move, may be necessary to make the effect sensible on any shore in a diminution of the surf; for we know that when wind ceases suddenly, the waves it has raised do not as suddenly subside, but settle gradually, and are not quite down till long after the wind has ceased. So though we should, by oiling them, take off the effect of wind on waves already raised, it is not to be expected that those waves should be instantly levelled. The motion they have recovered will, for some time, continue; and if the shore is not far distant, they arrive there so soon, that their effect upon it will not be visibly diminished. Possibly, therefore, if we had begun our operations at a greater distance, the effect might have been more sensible. And perhaps we did not pour oil in sufficient quantity. Future experiments may determine this.

I was, however, greatly obliged to Captain Bentinck for the cheerful and ready aids he gave me; and I ought not to omit mentioning Mr. Banks, Dr. Solander, General Carnac, and Dr. Blagden, who all assisted at the experiment, during that blustering unpleasant day, with a patience and activity that could only be inspired by a zeal for the improvement of knowledge, such especially as might possibly be of use to men in situations of distress.

I would wish you to communicate this to your ingenious friend, Mr. Farish, with my respects; and believe me to be, with sincere esteem,

Dear Sir,

Your most obedient
humble servant,
B. FRANKLIN.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

A SIMPLIFIED METHOD OF FINDING THE EQUATION OF EQUAL ALTITUDES.

By G. W. LITTLEHALES.

For a navigator who is out of connection with time-signals, the most simple and accurate method of regulating a chronometer is that of observing equal altitudes of the same celestial body on each side of the meridian of the place of observation. In case a star is chosen as the body to be observed, the mean of the two chronometer times corresponding to the equal altitudes is the chronometer time of transit; but, in the case of the sun, the mean of these times differs somewhat from the time of transit, since, in consequence of the change of the sun's declination in the interval between the observations, the equal altitudes do not occur at equal intervals before and after the transit. The corrections necessary to reduce the mean of the times at which the equal altitudes of the sun are observed to the time of transit is called the "Equation of Equal Altitudes."

Since the United States Hydrographic Office under the initiative of Rear-Admiral Joseph Edgar Craig, U. S. Navy, has completed the publication of the azimuths or true bearings of celestial bodies for all declinations up to 70°, north or south, at intervals of ten minutes of hour-angle for the entire circuit of the heavens, and for parallels of latitude of the observer extending to 70° from the Equator, and since these tables may be viewed as a complete tabulation, within the limits named, of the values of an angle opposite to a known side in any spherical triangle in which two sides and the included angle are given, therefore we may find from the azimuth tables the position-angle of a celestial body in any hour-angle by simply entering the tables with the declination in the latitude column and the latitude in the declination column

and finding the position-angle in the usual place of the azimuth. This being so, we are justified in bringing forward for use an abridged form of the "Equation of Equal Altitudes," in which the position-angle is an essential element in the calculation.

The principles of the problem of the "Equation of Equal Altitudes" are so clearly set forth in Commander Muir's new treatise on Navigation and Compass Deviations, p. 563 et seq., that it is unnecessary in this place to do more than refer to his book those readers who desire to familiarize themselves with the utility of the problem in connection with the finding of the corrections and rates of chronometers. The usual form of the "Equation of Equal Altitudes" is

$$t \,.\, dt = -\frac{t \,.\, d\delta \,.\, \tan L}{15 \sin t} + \frac{t \,.\, d\delta \,.\, \tan \delta}{15 \tan t}, \qquad (1)$$

which is deduced by differentiation, from the following fundamental equation expressing the relations of the parts of the astronomical triangle:

$$\sin h = \sin L \,.\, \sin \delta + \cos L \,.\, \cos \delta \,.\, \cos t,$$

in which the quantities have their usual significations. The differential equation takes the following form when all the parts are regarded as variable:

$$\begin{aligned} \cos h \,.\, dh = {} & \sin L \,.\, \cos \delta \,.\, d\delta + \sin \delta \,.\, \cos L \,.\, dL \\ & - \cos L \cos \,.\, t \sin \delta \,.\, d\delta - \sin L \,.\, \cos \delta \,.\, \cos t \,.\, dL \\ & - \cos L \cos \delta \sin t \,.\, dt, \end{aligned} \qquad (2)$$

or regarding only δ and t as variable, the differentials of the constant quantities h and L become zero and equation (2) becomes

$$0 = \sin L \,.\, \cos \delta \,.\, d\delta - \cos L \,.\, \cos t \,.\, \sin \delta \,.\, d\delta - \cos L \cos \delta \,.\, \sin t \,.\, dt$$

or

$$dt = \frac{\sin L \,.\, \cos \delta}{\cos L \,.\, \cos \delta \,.\, \sin t} \, d\delta - \frac{\cos L \,.\, \cos t \,.\, \sin \delta}{\cos L \,.\, \cos \delta \,.\, \sin t} \, d\delta$$

whence, changing signs in order to convert the second member from the expression of an error into the expression of a correction, and dividing the second member by 15 since $d\delta$ is expressed in seconds of arc while dt is required in seconds of time, and multiplying both members by t which represents ½ the elapsed apparent time between the observed equal altitudes on the opposite sides of the meridian of the observer, we arrive at once at the usual form of the equation, stated above as number 1.

If we divide both members of equation (2) by cos h, it becomes

$$dh = \frac{\sin L \cos \delta}{\cos h}\, d\delta - \frac{\cos L \,.\, \cos t \,.\, \sin \delta}{\cos h}\, d\delta + \frac{\sin \delta \,.\, \cos L}{\cos h} \,.\, dL - \frac{\sin L \cos \delta \cos t}{\cos h} \,.\, dL - \frac{\cos L \cos \delta \sin t}{\cos h} \,.\, dt,$$

and now make zero the terms in which the differentials of the constant quantities h and L appear, we shall have

$$0 = \frac{\sin L \cos \delta}{\cos h}\, d\delta - \frac{\cos L \cos t \sin \delta}{\cos h}\, d\delta - \frac{\cos L \,.\, \cos \delta \,.\, \sin t}{\cos h} \,.\, dt$$

or, calling M the position-angle,

$$0 = \cos M \,.\, d\delta - \cos \delta \sin M \,.\, dt$$

and

$$dt = \frac{1}{\cos \delta \tan M}\, d\delta = \sec \delta \,.\, \cot M \,.\, d\delta$$

whence, changing the sign of the second member in order to convert it from the expression of an error into the expression of a correction, and dividing the second member by 15 since $d\delta$ is expressed in seconds of arc, while dt is required in seconds of time, and multiplying both members by t which represents ½ of the elapsed time, we arrive at the following form for the "Equation of Equal Altitudes":

$$t \,.\, dt = -\frac{t}{15} \sec \delta \,.\, \cot M \,.\, d\delta.$$

This equation, besides being much easier to compute, is rid of the ambiguities of sign which attach to each of the two terms that compose the right-hand member of the usual form of the Equation. It will be observed that in this form the correction does not change sign unless the position-angle changes from a value less than 90° to a value greater than 90°; and that, when the position-angle has a value of 90°, the "equation" vanishes. We may, therefore, lay down the simple rule that, for values of the position-angle less than 90°, the correction should be added when the declination is decreasing and subtracted when the declination is increasing; and, for values of the position-angle greater than 90°, the reverse is case.

To illustrate the process of computation, let us compute the "Equation of Equal Altitudes" in the following example which is stated at page 569 of Muir's Navigation:

Ex. 207. April 5, 1905, at Sydney, N. S. W., Lat. S. 33° 51′ 41″, Long. E. 151° 12′ 23″, observed equal altitudes of the sun's lower limb, using artificial horizon, for C. C. on G. M. T. Mean of a. m. watch times $8^h\ 32^m\ 25.4^s$; C—W $2^h\ 21^m\ 20^s$. Mean of p. m. watch times $3^h\ 17^m\ 34.2^s$; C—W $2^h\ 21^m\ 21^s$. I. C. $+2'$, both a. m. and p. m. Find the C. C.

From the statement of the problem and from the Nautical Almanac,

$$t = 3^h\ 22^m\ 34.9^s = 3.3764^h$$
$$\delta = +5°\ 45'\ 52''$$
$$d\delta = +57.135''$$

Entering the Azimuth Tables with $-33°\ 52'$ in the declination column and $+5°\ 46'$ in the latitude column and $8^h\ 37^m$ or the supplement of $3^h\ 23^m$ in the hour-angle column (since the latitude and declination are of different sign or name), the value of M is found to be $133°\ 25'$.

Then

$$\begin{aligned} \log \sec \delta &= 10.00220 \\ \log \cot M &= 9.97598 \\ \log d\delta &= 1.75690 \\ \log t &= 0.52845 \\ \text{co-log } 15 &= 8.82391 \\ \log t \,.\, dt &= 1.08744 \\ t \,.\, dt &= +12.23 \text{ seconds.} \end{aligned}$$

The sign of this correction to the middle chronometer time is made positive because the position-angle is greater than 90° and the declination is increasing.

It should not escape attention that in those somewhat limited circumstances when the observer and the sun are situated on the same side of the Equator, and the declination is greater than the latitude, the true simplification in finding the "Equation of Equal Altitudes" consists in observing the sun's altitude at the time of elongation, for then the position-angle is 90° and the value of the "Equation," or the correction to the middle chronometer time of the observations, is vanishingly small.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

A NOTE ON NAVIGATION.

By COMMANDER H. C. GEARING, U. S. Navy.

Recently the writer on an occasion of duty found himself on a steamer bound from San Francisco to Coos Bay, Oregon. He made the acquaintance of the Captain, who extended to him many courtesies, and with whom he had many pleasant chats on topics both literary and professional. For the Captain is something of a poet; a poem of his on the Battle of Manila Bay had been read at the last banquet held by the First of May men in Washington; and he showed a wide and thorough reading of Military and Naval literature.

In passing Cape Mendocino he very kindly stopped his ship off Blunt's Reef Light-ship in order that there might be thrown into the boat that put off bundles of the latest newspapers and ephemeral literature that had been collected from the passengers and which the crew of the light-ship were sure to appreciate. That evening in his cosy cabin after some recitation of his poems and some discussion of historical naval battles, he spoke of the light-ship and of the days when no light-ship was there. Then he produced a large tracing of the coast and of Blunt's reef, to show me *his invention*, something he had found out himself and which, he said, was the wonder of brother masters of shipping plying those waters. When he neared Cape Mendocino, he said, he always wanted to know how far his course, if he continued on it, would clear Blunt's reef. "Now," said he, "I doubled the angle." I understood what he meant, which was the application of the rule that if for any bearing on the bow of a fixed point that bearing be doubled the distance run is the distance of the point at the time of the second bearing.

"This rule is not new," I said. "No, of course not," he

answered, "but what I do is this. When Mendocino is two points on the bow I take the time and patent log; and again when it is four point on the bow. That tells me how far off the Cape is. But what I want to know is how far off I shall be when it is abeam, and I want to know that before I get there, so as to change course if need be. So I have constructed this table," showing me a long table of distances for different runs between the two and four point bearings, "I have calculated these distances; I have run them out to many places, you see; this one to seven places just to see how far I could carry it." This was very interesting; the table was really carried out in one or two instances to that degree of refinement.

"But that is my invention, too," I replied, meaning by that that it was something I had found out for myself, "only I don't resort to any table of distances; the table is unnecessary. All you have to do is to multiply the last distance run by seven-tenths and there you have it, how far from Mendocino you will pass if you maintain your course." The Captain looked incredulous. But by applying the seven-tenths rule to his tabulated distances they were found to be in practical agreement in every case. He was convinced, but to preserve his proper opinion of his own elaborate method exclaimed "That's all right, but who would trust a deck officer such as we now get, with multiplying anything by seven-tenths. They can't do it and I'll stick to my table." This naturally led to a discussion of the qualifications and acquirements of officers of merchant vessels, which is another story.

The fact remained that we felt ourselves co-discovers of something of use and value. Most creditable to the master of this merchant coasting vessel is it that he had, unaided and untutored in mathematics, lighted on his handy problem in piloting. For myself, while I had seen the rule of "doubling the angle," in books, I had never seen in any text-book or book on Navigation, until I had run across Lecky's "Wrinkles," the prophetic feature of the problem, the part, too, which I think of greatest value. Lecky gives the multiplier as .71; it is really the one-half of the square-root of two [1.414], or .707. For practical application .7 will suffice. After I had lighted upon the rule I had frequent occasion to serve on examining boards for promotion of young officers and as occasions arose I have put this problem to them. "You are officer of the watch. The ship is steering

North. When a point you intend to pass, off which lies a danger, bears N. N. E., you take the bearing and log readings, and again when it bears N. E., the run by log being 10 miles. If you continue on your course, how far off from the point will you pass?" I am obliged to state that in no instance have I lighted on an officer thus examined, all graduates of the Naval Academy, who could answer the question off hand. I have had fellow members of boards object to the question being put on the ground that it was a "trick question." Some, probably the majority, were able, finally,

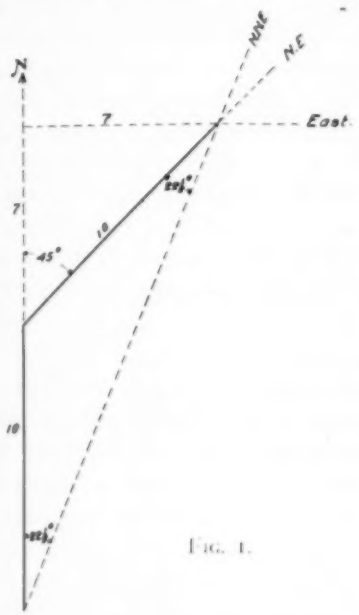

FIG. 1.

to work out the problem on paper. But that is a method hardly suitable for the bridge of a ship particularly if the night be stormy and you are encased in oil-skins. Some of these officers had been navigators of ships. Very few even knew what was meant by "doubling the angle on the bow" although I believe all knew the "bow and beam" rule which is a particular case of the general rule. I have asked the question of graduates of this year, with the same result; none of them could answer offhand, correctly. Now the rule is a most simple, handy, and useful one. Fig. 1 shows its solution with the data I have usually presented with it.

It is seen that if bearings of the object be taken at 2 and 4 points on the bow ($22\frac{1}{2}°$ and $45°$) seven-tenths of the run

between bearings will be the distance the point will be when passed abeam.

The midshipmen who answered the question as stated, all said the abeam distance would be 10 miles, and referred me to their text-book, "Navigation and Compass Deviations, Muir, 1906," as their authority. Turning to p. 214 of Muir, the prophetic part of the problem is given under the heading, **Distance of Passing an Object Abeam.** The rule stated is, "In case the first angle on the bow is 26½° and the second angle is 45°, the distance run between the two bearings will be the distance of passing the object abeam, if course and distance are unaffected by current." Full of my own method, i. e., bearings taken at 22½° and 45° which is an application of the general rule of "Doubling the angle on the bow," I hastily took the conclusion that the 26½° of Muir was a misprint for 22½°, assisted thereto by the fact that the rule immediately follows the paragraphs and figure devoted to "Doubling the Angle," and that my midshipmen friends seemed also to associate the rule with doubling the angle. The error of my conclusion has been pointed out to me by friends. This rule in Muir is correct. To me it is entirely novel, and is quite an ingenious solution of the problem.

It is suggested to the author that in revision of his book a figure similar to Fig. 2 might be given illustrating and proving the rule. The basis of it lies in the angle 26½°, which is (approx.) the angle whose tangent is one-half. More nearly the angle is 26° 34′, but 26½° suffices for work at sea.

(a) x = beam distance.

AB = run between bearings 26½° and 45°.

$$\tan 26\tfrac{1}{2}^\circ = \frac{x}{x+AB} = \tfrac{1}{2}$$

$$\therefore\ x = AB.$$

(b) Let $A'A$ = run between bearings 22½° and 26½°.

By seven-tenths rule.

$$x = \frac{7}{10} \times A'B \text{ or } A'B = \frac{10x}{7}$$

$$x = AB$$

$$A'A = A'B - AB = \frac{10x}{7} - x = \frac{3x}{7}$$

$$\therefore\ x = \frac{7}{3}\ A'A \text{ or } \frac{7}{3} \text{ run between } 22\tfrac{1}{2}^\circ \text{ and } 26\tfrac{1}{2}^\circ.$$

We have two rules, then, for determining beforehand the distance a ship will pass when abeam of an object. Both are equally simple. Perhaps, as the master of the Breakwater preferred his own method with a table of distances carried out to millionths of a mile, I prefer the seven-tenths rule, because I had worked it out for myself and have always used it. It is granted that 26½° is not quite so sharp an angle as 22½°, which is an advantage. But 26½° is an odd sized angle as nautical practice goes, while 22½° is two points and the second bearing is four points or twice two, and these angles are simply connected with compass courses when treated in points. I believe the seven-tenths rule will stick in the memory longer than a recollection of the angle 26½°.

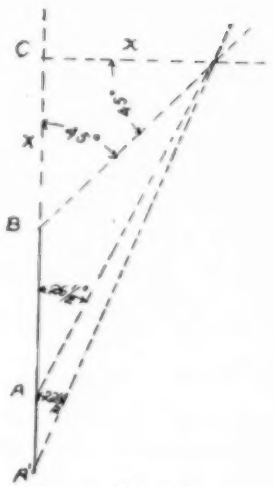

FIG. 2.

From a combination of these two rules there follows an interesting corollary; which is, that if bearings of an object at 22½° and 26½° on the bow be taken, then seven-thirds of the distance run in the interval will be the distance when abeam. Proof of this is shown in (*b*) of Fig. 2. Such a rule, better than guessing, might, on some rare occasion, be of value.

From the foregoing I believe it will not be amiss to re-state the above simple but valuable rules in piloting in order to inform those who do not know them and to impress on those who do know them their simplicity, handiness, and value and the great desirability of the officer of the watch applying them at all times while coasting. Of course corrections for current or tide in the distances run should always be noted.

Doubling the angle on the bow.—If for any bearing on the bow of a fixed point that bearing be doubled the distance run is the distance of the point at the time of the second bearing. The familiar problem of "bow and beam bearing" is but a particular case of the general rule.

To determine beforehand what distance your course will carry you from a given point.—Observe the object when it bears two

points on the bow, and again when it bears four points. *Seven-tenths* of the corrected run will be the distance when the object is abeam; or, Observe the object when it bears 26½° on the bow and again when it bears 45°. The corrected run will be the distance when the object is abeam.

One or the other of these rules, needing no calculations, no reference to tables, should be at the ready command of every officer navigating our ships.

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THE NEW NAVIGATION IN PRACTICE.

By LIEUT.-COMMANDER T. P. MAGRUDER, U. S. Navy.

Having read in Muir's Navigation and Compass Deviations (1906), that the "New Navigation," or Marcq Saint-Hilaire's method of drawing a line of position, is "superior to all other methods for drawing a line of position when the body observed is not on the prime vertical," the writer determined to use this method during the cruise of the fleet to southern waters the past winter. This was done and with such entirely satisfactory results, that I believe a brief explanation of the methods and results in practice, together with examples taken from actual practice, may induce other navigators to try the method, to the exclusion of the $\phi' \phi''$ sight, and to their own advantage.

An explanation of the theory and principles of Saint-Hilaire's method may be found in Chapter XX of Muir's Navigation; in Littlehale's Altitude, Azimuth, and Geographical Position, and in many standard works on Navigation. It is interesting, if not amusing, to note that Captain Lecky, an intensely practical navigator, says in his "Wrinkles" that "The 'New Navigation' is of the 'fancy' type—all very well with gentle zephyrs, but not suited to oilskin weather." Which goes to show that the good captain never used the method practically. It is easier to draw a line of position by Saint-Hilaire's method than by the $\phi' \phi''$ method even in "oilskin weather," though as a matter of fact few sights can be taken in "oilskin weather."

With a heavenly body on, or near, the prime vertical, the *time sight*, tangent method, leaves little, if anything, desired, for simplicity, accuracy, and quickness. Therefore, the problem of

obtaining a "fix" is usually resolved into finding the intersection of two lines of position found from observations of two bodies, one of which, usually, is near the prime vertical, and the other, at least 25° from it. Or, of course, the observations may be taken of the same body after a sufficient change of azimuth. Under this, the most ordinary condition, the quickest way to find the "fix" is by a combination of the time sight and Saint-Hilaire's methods. The *time sight* line being drawn, by assuming *one* Lat. and drawing the line through the position thus obtained on a bearing of 90° ~ Z (taken from the tables). See Examples I and II.

Using the sun, it may be necessary, at times, to work both sights (having a run between them) by Saint-Hilaire's method. See Example III.

In North latitude (greater than 15°), I have found the best, and by far the quickest way to obtain a "fix" at twilight is by observing Polaris and another star at nearly the same time. Observe a bright star at twilight while the horizon is still clearly defined, and immediately afterwards set the sextant at the approximate altitude of Polaris (the Latitude will generally do), using the telescope, and Polaris may be seen in the northern horizon before it is visible to the naked eye. See Example IV. In this case, the L. S. T. used to find the H. A. of Polaris (and thence the Latitude by Table IV, Nautical Almanac) is obtained from the L. S. T. obtained by the first sight. The intersection is readily computed by using the longitude factor *F*. (See *Muir*, p. 609).

In all cases of observing two stars simultaneously, some work may be saved by noting the error of the watch or chronometer on L. S. T. for the first sight, and obtaining that for the second sight, by applying the sidereal interval between sights to the sidereal time of the first sight. In using log. tables not having *haversines*, it is well to note that the log. sin of t (in $^h\ ^m\ ^s$) equals the log. sin $\frac{1}{2}t$ (in $^\circ\ '\ ''$).

In the examples given, the intersection of the lines, or the "fix" is computed. This is done by inspection from the traverse tables so easily and readily, that it may be preferred to plotting the lines on a chart. Particularly, when the latter will necessitate the construction of a chart or of using a coasting chart (changing the merids. to the longitude in),—which is the case when the

sailing chart is on such a small scale that plotting small distances will be inaccurate. The computed position can be laid down very quickly by laying off from the corner of a right angled piece of paper, the latitude and longitude from a parallel and meridian of the chart in use and then, by making these points coincide with the parallel and the meridian, the corner of the paper will be at the desired position. If, however, the navigator prefers the graphical method of finding the intersection of lines when using Saint-Hilaire's method, transparent celluloid triangles will be found a convenience. This suggests the query—Would not transparent celluloid parallel rulers be an improvement over those now supplied?

Many ships are furnished with Littlehale's "Altitude, Azimuth, and Geographical Position," a graphic solution of the astronomical triangle. To use this graphic method, one must be familiar with Saint-Hilaire's method. In using Littlehale's plates, the writer found that small german silver parallel rulers were of material assistance.

In the fleet, navigators must have the position ready for signalling at noon and 8 p. m. The noon is usually that of a standard meridian and *not* local apparent noon. A good way to get an accurate position to be signalled is by a line obtained in the middle forenoon (Saint-Hilaire's method) combined with a latitude obtained with a constant corrected for time from L. A. N. (See Muir's Navigation, p. 535). This is another opportunity to use the longitude factor already mentioned. Having the tabulated constants and F in his deck note book, the navigator is in a position to have the signals hoisted upon the stroke of the bell, if need be.

The following examples of the use of the so-called "New Navigation" are taken from actual sights in the work book of the navigator of the *U. S. S. Iowa*. The altitudes, declination, equation of time, etc., given were corrected in the usual way. The results were checked by comparison with the positions of several other vessels.

With each example a figure is drawn for the purpose of explanation. In practice, however, this is not at all necessary. It may be advisable for one beginning the use of the method, to draw a rough sketch of the lines to assist in the proper application of the corrections, signs, etc.

EXAMPLE I.

About 7 p. m., April 13, 1907; Lat. 31° 00′ N. and Long. 74° 20′ W. by D. R., observed stars Aldebaran and Rigel.

ALDEBARAN.

	h m s		° ′ ″		
Ch.	11 31 57	h	35 56 20		
C. C.	+ 22 01	L	31 00 00	sec	.06693
G. M. T.	11 53 58	p	73 40 40	cosec	.01787
R. A. O.	1 22 06	$2s$	140 37 00		
Cor.	1 57	s	70 18 30	cos	9.52758
G. S. T.	13 18 01	$s-h$	34 22 10	sin	9.75168
R. A.	4 30 35			2	9.36406
G. H. A.	8 47 26		h m s		9.68203
		H. A.	3 49 57		
		G. H. A.	8 47 26		
		Long.	4 57 29 = 74° 22′ W.		$Z_1 = N\ 92°\ W.$

$2^m\ 32^s$ (sid. int.) later observed star

RIGEL.

		h m s			
G. S. T. [1st sight]		13 18 01			
Cor.		2 32			
G. S. T.		13 20 33			
Long.		4 57 29			
L. S. T.		8 23 04			
R. A.		5 10 04	2		log .30103
t		3 13 00	sin	9.61143	2 sin 9.22287
		° ′ ″			
	Lat.	31 00 00			cos 9.93307
	dec.	8 18 30 S			cos 9.99542
	$L-d$	38 18 30	N. C.	.77375	
			−	.28339	log 9.45239
	h	29 21 50	N. S.	.49036	
	obs. alt.	29 20 00			
	a	1.8 N			

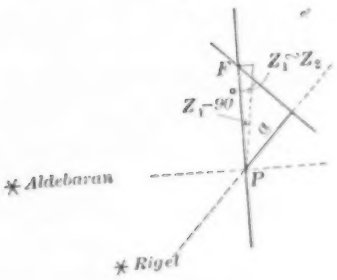

FIG. 1.

	°
Z_1	N 92 W
Z_2	N 121 W
$Z_1 \sim Z_2$	29

To find the intersection of the lines: With $Z_1 \sim Z_2$ as a course, and a as dep., $PF = 3.7$. (See Fig. 1.) Then with PF and course $Z_1 - 90°$, by inspection $l = 3.7'$ N. and $D = .2'$ W. Whence

		° ′		° ′
Position of P	Lat.	31 00 N	Long.	74 22 W
l		3.7 N	D	.2 W
" " F		31 03.7 N		74 22.2 W

EXAMPLE II.

About 8 a. m., April 12, 1907, Lat. 25° 07′ N., Long. 74° 20′ W., by D. R., observed the ⊙.

	h m s		° ′ ″		
Ch.	1 09 17	h	33 17 00		
C. C.	29	L	25 07 00	sec	.04314
G. M. T.	1 09 46	p	81 37 20	cosec	.00466
Eq. T.	1 03	$2s$	140 01 20		
		s	70 00 40	cos	9.53381
G. A. T.	1 08 43	$s-h$	36 43 40	sin	9.77671
				2 |	9.35832
L. A. T.	8 11 43				9.67916
Long.	4 57 00 = 74° 15′ W		Z = N 97° E		

Thence ran N. 4° W., true, 13 k. when again observed ⊙. Applying run to 1st sight, position of P (see Fig. 2) is, Lat. 25° 20′ N. and Long. 74° 14′ W.

	h m s					
Ch.	3 38 03					
C. C.	28					
G. M. T.	3 38 31					
Eq. T.	1 01					
G. A. T.	3 37 30					
Long.	4 56 56		2		log	.30103
L. A. T.	10 40 34		sin	9.23660	2 sin	8.47320
		° ′ ″				
	Lat.	25 20 00 N			cos	9.95609
	dec.	8 25 00 N			cos	9.99530
	$L-d$	16 55 00	N. C.	.95673		
			−	.05316	log	8.72562
	h	64 38 00	N. S.	.90357		°
	⊙	64 34 00			Z_1	N 97 E
	a	4.0′ N			Z_2	N 128 E
					$Z_1 \sim Z_2$	31

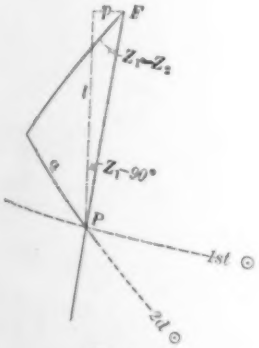

FIG. 2.

Proceeding as in Example I, PF (Fig. 2) = 7.8, l = 7.7′ N., and D = 1′ E.

		° ′		° ′
Position of P	Lat.	25 20.0 N	Long.	74 14 E
	l	7.7 N	D	1 W
" " F		25 27.7 N		74 13 W

From the time of 2d sight to noon, ran 14 k. N. 4° W., true, making noon Lat. from forenoon sights 25° 41.7′ N. The Lat. by observations at noon was 25° 42.6′ N.

EXAMPLE III.

About 8.30 a. m., Jan. 3, 1907, Lat. 34° 07′ N., Long. 74° 41′ W., by D. R., observed the ⊙.

	h	m	s
Ch.	1	33	01
C. C.		1	21
G. M. T.	1	34	22
Eq. T.	−	4	16
G. A. T.	1	30	06
Long.	4	58	44
L. A. T.	8	31	22

		°	′	″		
L	34	07	00			
d	22	54	15	S		
$L-d$	57	01	15		N. C.	.54436
					−	.29477
h	14	27	11		N. S.	.24959
⊙	14	24	00			
a_1			3.2′	N		

2		log .30103
sin	9.64307	2 sin 9.28814
		cos 9.91798
		cos 9.96434
		log 9.44949

$Z_1 = \text{N } 131° \text{ E}$

Thence S. 4° E., true, 22 knots and at about 10.45 a. m., again observed the ⊙. The point P (Fig. 3) is obtained by applying the run and a_1 (course Z_1 or, $180° + Z_1$) to the first position by D. R., as follows:

Course.	Dist.	N	S	E	W
S 4° E	22.0		21.9	1.5	
N 49 W	3.2	2.1			2.4
			19.8		.9

			°	′			°	′	
Position	D. R.	Lat.	34	07.0	N	Long.	74	41	W
	l			19.8	S	D		1	W
	P		33	47.2	N		74	42	W

	h	m	s
Ch.	3	45	37
C. C.		1	21
G. M. T.	3	46	58
Long.	4	58	48
L. M. T.	10	48	10
Eq. T.	−	4	20
L. A. T.	10	43	50

		°	′	″		
L	33	47	15	N		
d	22	53	45	S		
$L-d$	56	41	00		N. C.	.54927
					−	.04189
h	30	29	22		N. S.	.50738
⊙	30	29	00			
a_2			.4′	N		

2		log .30103
sin	9.21855	2 sin 8.43710
		cos 9.91966
		cos 9.96556
		log 8.62215

	°
Z_1	S 49 E
Z_2	S 20 E
$Z_1 \sim Z_2$	29

FIG. 3.

Hence proceeding as above, the position of F, or the "fix" is Lat. 33° 48′ N., Long. 74° 42′ W. This Lat. run up to noon was 33° 36′ N. The Lat. at noon by observation was 33° 37′ N.

The important thing to note in Example III is to combine a with the run to find the position of P. Had a been *toward* the sun its course would have been S. 49° E.

EXAMPLE IV.

Evening twilight, April 13, 1907, at $7^m\ 44^s$ (sidereal interval) after observing star Rigel (Example I), observed Polaris.

	h m s		° ′ ″	
L. S. T.	8 23 14	(obs. of Rigel)		
Sid. Int.	7 44			
L. S. T.	8 30 58	alt.	30 43 10	
R. A.	1 25 48	Cor.	20 42	(Table IV, N. A.)
t	7 05.2	Lat.	31 03.9 N	

Assumed position at time of observing Rigel was: Lat. 31° 00′ N., Long. 74° 22′ W. From the results in Example I, $a = 1.8$ N., and $Z =$ S. 59° W. Run between sights of Rigel and Polaris 1.3 k., N. 3° W. Hence position of P, Fig. 4, is Lat. 31° 02.2′ N., and Long. 74° 20.5′ W. The intersection of the lines is obtained most readily by the use of the *longitude factor* from the tables; in this example it is $0.7\ \frac{\text{NW}}{\text{SE}}$. From which the position is Lat. 31° 04′ N., Long. 74° 21.5′ W. This agrees very closely with the results obtained in Example I.

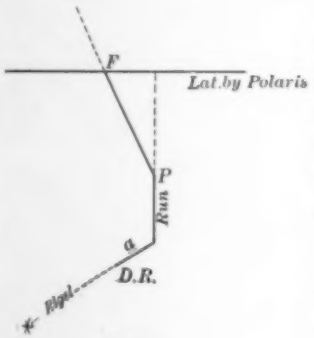

FIG. 4.

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NAVIGATING WITHOUT HORIZON.

By CAPTAIN BRADLEY A. FISKE, U. S. Navy.

I have had the idea for many years that ships could find the altitude of a heavenly body, when the horizon could not be seen, by taking the angle between that body, and the water-line, or other part, of some ship under it, and at a known distance from the observer; the dip being found by computing the angle subtended at that distance by the difference in height between the observer's eye and the part of the target-ship angled on.

I have suggested this method to a great many officers at different times. They have all said that they could see no reason why it would not work, and that it ought to be tried.

But it was never tried by anyone, so far as I know, until the night of August 2, 1907, when it was tried by Lieutenant-Commander Yates Stirling, Jr., to whom I had suggested that he try it whenever he got an opportunity. Mr. Stirling was then navigator of the U. S. S. *Arkansas,* and I the captain.

I will let Mr. Stirling tell of the incident in his own words. "On the night of August 2, 1907, the *Arkansas,* in company with the other ships of the Practice Squadron, was standing on a course N. ¼ E. (Magnetic), to make Seguin Island at the mouth of the Kennebec River. The ships were enshrouded in a dense fog, and had been steaming in this fog since leaving Block Island 16 hours before. About 10.30 p. m., the fog became less dense; and about 10.35 it cleared away sufficiently to make out distinctly the lights of the *Florida* and *Olympia.* Overhead the sky was cloudless and many stars were visible; but the horizon could not be seen.

"It had been many times suggested by Captain Fiske, that he would like to see tested a method of taking a sight in a fog, using a ship or a boat as a base from which to measure the altitude. It occurred to me that this was a very favorable oppor-

tunity; and I decided to attempt to get the Latitude by altitudes of the Pole Star.

"I detailed one midshipman with stadimeter to take the distances of the *Florida* and *Olympia* at the times of sights, and one to mark the times.

"The ship was steered so as to bring the stern lights of the *Florida* and *Olympia* directly under the star, successively.

"The altitudes were taken by me, Polaris being brought down very readily to the stern lights of the *Florida* and *Olympia*, just 500 and 1000 yards away respectively, as measured by the stadimeter.

"The actual computation of the sight on the *Olympia* is shown below. The computation of the sight on the *Florida* was the same, except that the dip was 29′ 48″ instead of 17′ 46″. The Latitude found was 42° 46′ 09″ in the case of the *Olympia* and 42° 43′ in the case of the *Florida*.

$$\text{Dip} = \tan^{-1}\frac{\text{height}}{\text{distance}}$$

Height	15.5	log 1.19033
Dist.	3000	log 3.47712
Dip	17′ 46″	tan 7.71321

	h	m	s	
W. T.	3	29	30	
C.—W.		1	51	
C. F.	3	31	21	
C. C.		+	38	
G. M. T.	15	31	59	(Aug. 2)
☉'s R. A.	8	39	43	
Cor.		+	02	33
G. S. T.	24	14	15	
Long.	4	38	20	
L. S. T.	19	35	55	
✱'s R. A.	1	26	10	
✱'s H. A.	18	09	45	

or (—)	87° 33′ 45″	cos 8.62870
p	71′.6	log 1.85491
ϕ	3′ 03″	log 0.48361

✱'s d	88° 48′ 23″		
p	71′.6		
✱'s R. A.	1h 26m 10s		
✱'s Alt.	43° 08′ 00″		
	°	′	″
Dip.	(—)	17	46
Ref.	(—)	1	02
Cor.	(—)	18	48
h	42	49	12
ϕ	(—)	3	03
L	42	46	09 N

"At 1.30 a. m. I got a sounding in 31 fathoms on Platt's Bank, which fixed our position within one mile. I worked back from this position, and found that the Latitude at the time of the sight of Polaris was 42° 45′ 30″." Naturally, I was delighted with Mr. Stirling's success; so in the forenoon of the next day, August 3, 1907, when the ship was at anchor in a dense fog off the mouth of Kennebec River, Maine, and I saw another opportunity to test

the method, I directed Lieutenant H. C. Cocke and Midshipman J. C. Hunsaker to try to get observations near noon; and I sent out the dinghy sunward to be used instead of the horizon. Although the sun was shining brightly, the fog was so thick that the boat could be seen only a short distance; this distance was found to be 173 yards. Mr. Cocke's and Mr. Hunsaker's observations of altitude agreed within one minute. Mr. Cocke's altitude gave a Latitude of 43° 46′, Mr. Hunsaker's 43° 47′. The position of the ship, as determined by observations on Seguin Island, after the fog lifted, showed the Latitude to be 43° 42′ 15″. The mean of the two observations therefore was 4′ 15″ in error. Inasmuch as the observers secured very good observations, the cause of this error lies probably in an incorrect measure of the distance; which, on account of the distance being so small, would make a great deal of difference in the dip.

Thinking that this might be the case, I directed Midshipman Hunsaker to get a Longitude observation on the afternoon of August 5, 1907, while at anchor off Bath, Maine. I sent out a whale-boat to sunward, and arranged carefully that the observer of the altitude on board, and the observer with stadimeter in the boat should take their observations simultaneously.

The tide was running strong, and it was hard to keep the whale-boat at a constant distance; and as its distance was very small, only about 155 yards, the mean of the altitudes was not taken; but the observations were worked out singly. As a matter of fact, only four were worked out. The Longitudes obtained were 69° 53′ W., 69° 45′ W., 69° 51′ W., and 69° 47′ W.

The mean of these observations is 69° 49′ W. The correct position as taken from the chart, whereon it was exactly located, was 69° 48′ 35″ W.

I respectfully submit this method to the consideration of mariners generally and naval officers particularly. At times it may prove of great value. Its most obvious use would seem to be in fleet work at night, when some heavenly body can be seen. All the commander-in-chief has to do, is to order some ship to take an observation. That ship will then steam to a point where some other ship of the fleet is under the moon, or some star or planet, and take the angle between it and some convenient line or point on the target ship. If desired, she can then take a similar observation on another heavenly body, bearing in such a direction from the first heavenly body as to give a good cut.

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THE IDENTIFICATION OF STARS IN CLOUDY WEATHER.

By LIEUT.-COMMANDER ARMISTEAD RUST, U. S. Navy.

Referring to "Notes on the use of the Great Circle Sailing Chart for the Solution of Problems in Nautical Astronomy," published in No. 116 of the U. S. NAVAL INSTITUTE and the method for the identification of stars described, it will be shown that such problems may be readily solved with the aid of the Azimuth Tables. (H. O. Pub. Nos. 71 and 120.)

Problem 1. At sea, February 26, 1901, 6.30 p. m., L. M. T., weather overcast and cloudy observed the altitude of an unknown star, of about the second magnitude, through a break in the clouds, 29° 30′ (true), bearing N. 74° W. (true). What is the name of the star? Position by dead reckoning Lat. 35° N. Long. 60° W.

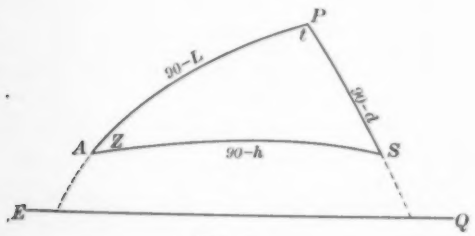


FIG. 1.

In Fig. 1.—P is the pole (elevated), A the zenith of the observer and S the position of the star.

Given $AP = 90 - L$; $AS = 90 - h$ and $Z =$ the Azimuth; to find $t =$ the hour angle of star and $d =$ the declination.

Reduce the observed altitude and azimuth to true and find the Local Sidereal Time at ship.

Shift the pole of the triangle PAS from P to A; then renaming the parts as shown in Fig. 2 we find the hour angle thus:

Enter the Azimuth Tables in the Latitude of the ship with the azimuth as an hour angle and the altitude as a declination; the corresponding azimuth is the hour angle of the star.

Then $\cos d = \sin z \cos h \operatorname{cosec} t$.

It is evident, too, from Fig. 1 that the azimuth of the star from A is the Great Circle Course from A to S in Latitude $= d$.

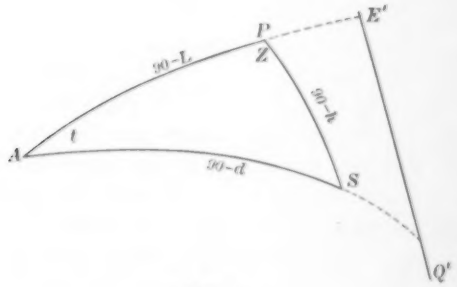


FIG. 2.

To solve Problem 1. $L = 35°$ N.; $h = 29°\ 30'$; $Z =$ N. $74°$ W.

$74° = 4$ hrs. 56 min.

	h	m	s
L. M. T.	6	30	00
R. A. M. S.	22	22	33
Cor. G. M. T.	+	1	43
L. S. T.	4	54	16
Star H. A.	4	49	36
Star R. A.	0	04	40

Entering the Azimuth Tables (H. O. No. 120) in Lat. 35°; latitude and declination same name with 4 hrs. 56 min. as hour angle and for 29° 30′ dec. we find the azimuth 72° 24′ = 4 hrs. 49 min. 36 sec. the required hour angle.

Then we have:

$Z = 74°$	sin	9.98284	
$h = 29°\ 30'$	cos	9.93970	
$t = 72°\ 24'$	cosec	0.02082	R. A. of Star = 0 hrs. 4 min. 40 sec.
$d = 28°\ 38'$	cos	9.94336	Dec. " " = 28° 38′ N

In the Nautical Almanac these correspond to α Andromedae.

R. A. 0 hrs. .03 min. 19 sec.

Dec. 28° 33′ N.

2. Ordinarily the azimuth may be observed with sufficient accuracy for the purpose of identification but it is not always convenient to take the bearings and conditions may be such as to make them inaccurate.

The azimuth may be obtained, however, from the observed altitudes without the use of the compass.

From No. 285 Chauvenet's Trigonometry (10th edition) we have:

$$\Delta h = \cos Z \Delta L + \cos M \Delta d - \cos L \sin Z \Delta t.$$

Let L and d be constant then $\Delta h = -\cos L \sin Z \Delta t$ and if $\Delta t = 15'$ then we find $\Delta_1 h = -15 \cos L \sin Z =$ the change of altitude in one minute of time or

$$\sin Z = -\frac{\Delta_1 h}{15} \sec L.$$

$\Delta_1 h$ may be found from the difference between two altitudes and the corresponding interval of time. To be exact $\Delta_1 h$ should be corrected for the run of the ship; Correction $= D \cos$ (Course $-$ Azimuth) where $D =$ distance run in one minute. In identifying stars this correction may be neglected.

Problem 2. At sea, Feb. 6, 1903. Latitude 15° 53′ S., Long. 38° 12′ W. Observed the following altitudes of a star bearing about W. N. W. Cloudy weather with heavy sea and too much motion on the ship to obtain a bearing by compass. What star was observed?

Obs. altitudes. ° ′	Watch times. h m s
20 18	5 05 07
19 58	06 38
19 39	08 00

C − W = 3 hrs. 08 min. Chro. fast.
G. M. T. 20 min. 09 sec.
Correction for I. C. Dip and Refraction, −7′ 00″

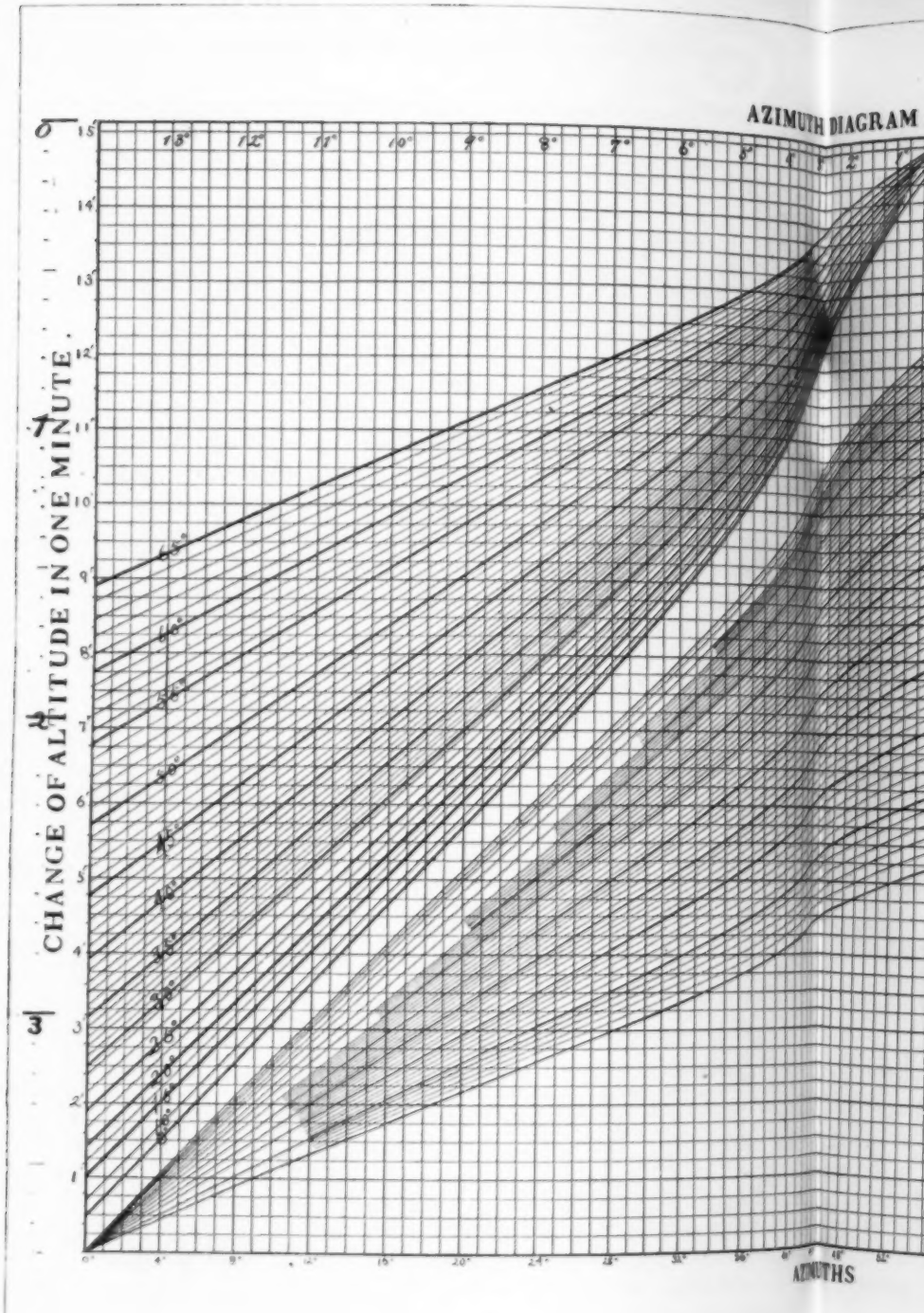
In 2 min. 53 sec. change in altitude = 39′ and $\Delta_1 h = -13.52'$

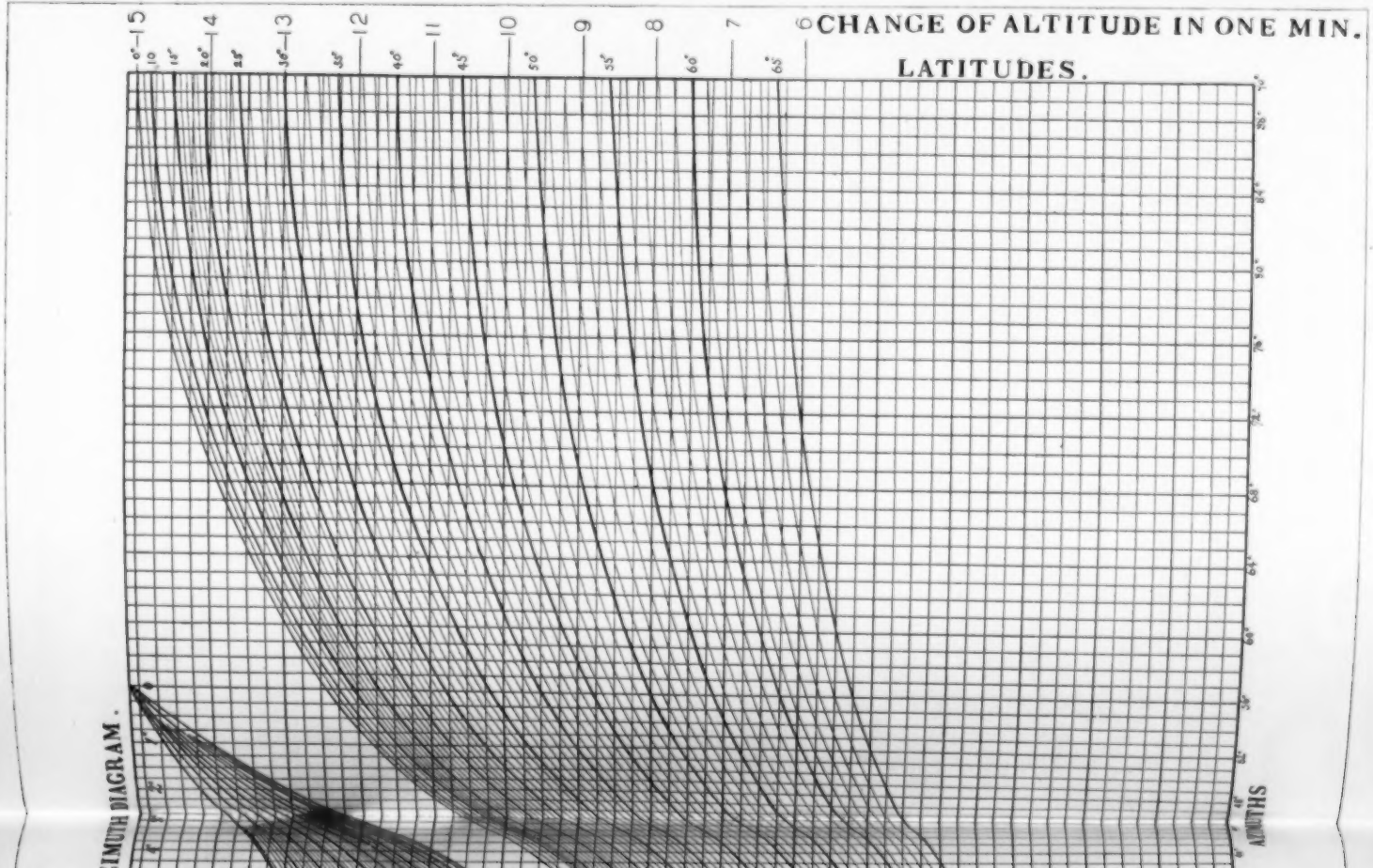
Lat.	15° 53′	sec	10.01691
$-\Delta_1 h$	13.52′	log(−)	1.13098
	15	colog	8.82391
Z	S 110° 25′ W	sin(−)	9.97180
h	19° 51′ 20″	cos	9.97339
t	64° 30′	cosec	10.04451
d	12° 26′ N	cos	9.98970

We find from the Nautical Almanac that the observed star was α Leonis (Regulus).

	h m s
w. t.	5 06 35
C − W	3 08 13
Chro.	8 14 48
C. C.	− 20 09
G. M. T.	19 54 39
R. A. M. S.	20 57 50.4
Cor.	+ 03 16.2
G. S. T.	16 55 45.6
Long.	2 32 48
L. S. T.	14 22 57.6
Star's H. A.	4 18 00
" R. A.	10 04 57.6

3. It is always better to take a compass bearing as a check even though a rough one as this with the altitude and Latitude will enable the observer to decide whether the Latitude and Declination are of the same or contrary names. This is necessary in order to find the Hour Angle from the Azimuth Tables.


AZIMUTH DIAGRAM
CHANGE OF ALTITUDE IN ONE MINUTE.
AZIMUTHS


CHANGE OF ALTITUDE IN ONE MIN.
LATITUDES.
0°–15
10°
14°
20°
25°
30°–13
35°
12
40°
45°
11
50°
10
55°
9
60°
8
65°
7
6
AZIMUTH DIAGRAM.
AZIMUTHS

There will be no difficulty in determining the name of the Declination except when the star is near the Equator. After computing the Declination it is well to verify its sign by entering the Azimuth Tables with the Hour Angle and Declination to see whether the azimuth so found agrees with that used in the computation.

Problem 3. At sea, August 10, 1904, about 5.30 a. m. Latitude 11° 37′ N. Longitude 81° 09′ W. Correction for Dip Refraction and I. C. —9′ 00″. Observed the following altitudes of a bright star bearing about E. S. E.

Watch times. h m s	Obs. altitudes. ° ′
5 24 35	23 36
26 55	24 07.5
35 43	26 04

When the watch showed 5 hrs. 35 min. 43 sec. the G. S. T. was 8 hrs. 12 min. 17 sec. As the ship was rolling heavily no accurate bearing could be taken. What was the star?

It is evident from the approximate bearing and altitude that the star is in South Declination. When $d = 0°$; Meridian altitude $= 90 - L = 79°\ 23'$ in this case—evidently too great an altitude for this star to reach.

We find $\sin Z = -\frac{148}{167} \sec L$

	° ′		
L	11 37 N	sec	10.00899
148		log (−)	2.17026
167		colog	7.77728
Z S	64 47 E	sin (−)	9.95653
h	25 55	cos	9.95397
t	58 04	cosec	10.07126
d	16 30 S	cos	9.98176

To find the hour angle in this case we must enter the Azimuth Tables with the supplement of the azimuth found $= 115°\ 13' = 7$ hrs. 40 min. 52 sec. as an hour angle, and in the 26° column we find 58° 04′ for the hour angle of the star.

	h m s	
G. S. T. of obs.	8 12 17	
Long.	+5 24 36	
L. S. T. of obs.	2 47 41	
Star's H. A.	3 52 16	(East)
" R. A.	6 40 07	

Star's R. A. $6^h\ 40^m\ 07^s$
" Dec. 16° 30′ S

These correspond to α Canis Majoris (Sirius).
R. A. $6^h\ 40^m\ 55^s$
Dec. 16° 35′ S

Enter the Azimuth Tables in Latitude 12° Declination 16° 30′ —Contrary Name—with hour angle 58° 04′ $= 3^h\ 52^m\ 16^s$ we find $Z =$ N. 115° 28′ E. or S. 64° 32′ E. which shows that the Declination has been given the correct name. If we enter with Latitude and Declination the same name we find $Z = N.\ 78°\ 05'$ E.

4. In all cases the name of the Declination may be readily found from the following table for which the writer is indebted to Professor H. L. Rice, U. S. Navy, Assistant Astronomer of the U. S. Naval Observatory, through the courtesy of the Superintendent, Rear-Admiral Asa Walker, U. S. Navy.

VALUES OF B.

Altitudes.	For Azimuths North toward West or North toward East.										Altitudes.
	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	
°	°	°	°	°	°	°	°	°	°	°	°
10	16.0	16.0	15.9	15.7	15.4	14.9	14.1	12.5	8.9	0.0	10
20	14.0	13.9	13.8	13.4	12.9	12.1	10.8	8.6	5.1	0.0	20
30	12.0	11.9	11.7	11.3	10.6	9.6	8.2	6.1	3.3	0.0	30
40	10.0	9.9	9.6	9.2	8.5	7.5	6.2	4.4	2.3	0.0	40
50	8.0	7.9	7.7	7.2	6.5	5.7	4.6	3.2	1.7	0.0	50
60	6.0	5.9	5.7	5.3	4.8	4.1	3.2	2.2	1.1	0.0	60
70	4.0	3.9	3.8	3.5	3.1	2.6	2.1	1.4	0.7	0.0	70
80	2.0	2.0	1.9	1.7	1.5	1.3	1.0	0.7	0.4	0.0	80
90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	90
Altitudes.	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	Altitudes.
	For Azimuths South toward West or South toward East.										

Express the Latitude in degrees and tenths as B in the Table.
Mark North Latitude + and South Latitude —.
When Z is found at the top of the Table B is +.
When Z is found at the bottom of the Table B is —.
The Declination has the sign of $B + \frac{\text{Latitude}}{5}$.

5. The relation $\text{Sin } Z = -\frac{\Delta_1 h}{15} \sec L$ is shown by the Azimuth Diagram. The azimuth obtained from this diagram being negative must be reckoned from the depressed pole. The sine being the same for the angle and its supplement the bearing by compass should be noted roughly to determine the quadrant in which the azimuth lies.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE FRENCH NAVAL MANŒUVERS OF 1907.[1]

(From *Le Yacht* and *Le Moniteur de la Flotte.*)

Translated by PHILIP R. ALGER.

For these manœuvers the Mediterranean and Northern Squadrons were combined, Vice-Admiral Touchard, the commander-in-chief of the Mediterranean Fleet, being in supreme command.

It was originally intended that the operations should extend over a period of fifteen days in the Atlantic, and for another fifteen in the Mediterranean, but the time was somewhat curtailed. There was no mobilization of either ships or men for the manœuvers, as the elections for the Departmental Councils prevented the reservists from being called out, but the ships of the 3rd Battleship Division of the Mediterranean, with the destroyer *La Hire* were brought up to their full sea-effective on the 25th of June, the ships of the 4th Battleship Division, which only took part during the last week of the manœuvers, remaining with their reduced complements. The torpedo-boat divisions of the 1st line, and the submarine flotillas were, however, temporarily mobilized, and placed under the orders of the commander-in-chief.

The Northern Squadron, under Vice-Admiral Jauréguiberry, consisting of the armored cruisers *Léon Gambetta* (flagship of

[1] NOTE BY TRANSLATOR.—The French Naval Manœuvers of 1907, in the main, consisted of tactical exercises directed by Vice-Admiral Touchard, in accordance with the methods advocated by Vice-Admiral Fournier, and to some extent tested by the latter in the manœuvers of 1905 and 1906.

The fundamental idea of Fournier's tactics is the arrangement of each division, composed of three ships, in a triangular group; the division commander follows the movements of the Commander-in-Chief, while the other two ships of the division merely endeavor to keep in positions from which their gun fire can be efficiently directed against the enemy.

In this way the triangle which each division forms at every moment is an irregular and deformable one, and the fleet is an assemblage of such triangular groups, each following the Commander-in-Chief's movements.

commander-in-chief), *Admiral Gueydon, Dupetit Thouars, Gloire, Admiral Aube,* and *Jeanne d'Arc,* with the cruiser *Forbin,* left Royan on July 1, and after touching at the Isle d'Aix, proceeded towards the southern coast of Portugal. Off Lisbon the squadron was joined by the *Cassini* and 5 destroyers.

The Mediterranean Squadron, on its side, rendezvoused at Mers-el-Kebir on July 1, being composed as follows:

1st Division.—Battleships *Suffren* (flagship of commander-in-chief), *Charlemagne,* and *République.*

2d Division.—Battleships *Saint Louis* (flagship of Rear Admiral Manceron), *Carnot,* and *Gaulois.*

3d Division.—Battleships *Masséna* (flagship of Rear Admiral Kiésel), *Bouvet,* and *Jauréguiberry.*

Light Division.—Armored cruisers *Jules Ferry* (flagship of Rear Admiral Krantz), *Victor Hugo, Condé,* and *Desaix.* Protected cruisers *Du Chayla, and Galilée.* Destroyers *La Hire, Dard, Carabine, Mousqueton, Arbelete, Sarbacane,* and *Claymore.*

After leaving Mers-el-Kebir the fleet steered for the Straits of Gibraltar, passing through on the night of July 3. On the 4th the fleet was divided into two groups (A and C), and the first phase of the manœuvers began, its theme being as follows:

Groups B and C have to effect a junction with each other, both knowing that an enemy A, stronger than either alone, but weaker than the two together, will try and prevent their junction.

Group C is to start from a point fixed on the parallel of Cape Mazagan, to the east of the 15th degree of longitude; Group A taking up its station between B and C, both of which know the other's position on a certain day and hour, and if the junction is effected, the two combined squadrons are to seek A, and if possible, bring him to action before the time fixed for the conclusion of this phase, viz., the evening of the 7th July.

The maximum speeds are fixed: for Squadron A, 12 knots; for Squadron B, 15 knots; for Squadron C, 10 knots.

All the cruisers are considered of equal value.

B or C are to be considered as destroyed, if caught alone at a distance of under 4 miles from A. Every cruiser which remains an hour under fire within a distance of 3 miles from a superior force is to be considered captured.

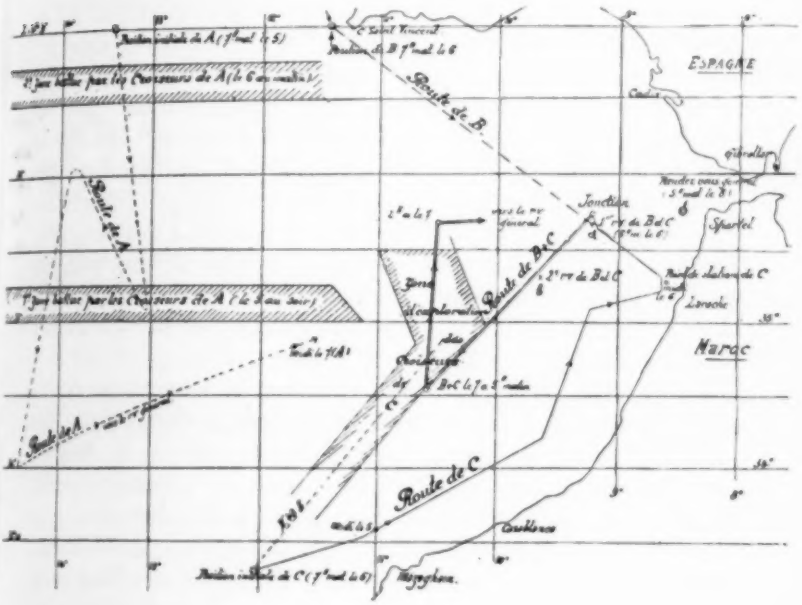
Group A (Vice-Admiral Touchard).—*Suffren, Charlemagne, République, Masséna, Carnot, Jauréguiberry;* Light Division—

Jules Ferry, Victor Hugo, Condé, Dupetit Thouars, Admiral Gueydon, and 6 destroyers.

Group C (Rear Admiral Manceron).—*Saint Louis, Gaulois, Patrie;* Light Division—*Desaix, Du Chayla, Galilée, La Hire.*

Group B (Vice-Admiral Jauréguiberry).—*Léon Gambetta, Admiral Aube, Gloire, Jeanne d'Arc, Forbin, Cassini,* and 6 destroyers.

1st Phase.—The exercises began at 7 a. m., July 5.



Squadron A was then 200 miles west of Cape St. Vincent. Having too few cruisers to effectively watch a field limited by the meridian of 15° W. and the parallels of 35° and 42° N., A apparently reasoned that C, being slow, would take the shortest route to meet B by going directly towards Cape St. Vincent. Accordingly A stood south while his cruisers explored a long strip between longitudes 11° and 15°, and latitudes 33° and 37°. Having seen nothing, on the following day the cruisers went further north, between 36½ and 37°. There, again, they found nothing. Meanwhile the *Dupetit Thouars* having learned by wireless that the junction had been effected, A collected his ships and stood, without

having met a single one of the enemy, towards the general rendezvous, fixed, in 10° longitude and the latitude of Cape Spartel, for 5 a. m., July 8.

During this time Admiral Jauréguiberry executed a very simple program which was completely successful. He had fixed his point of junction with C in 35° 40′ north latitude, and 9° 12′ west longitude, about 50 miles northwest of Larache, at 5 o'clock in the evening. Admiral Manceron, whose initial position was 60 miles off Mazagan, had then only to follow the coast line towards the north of Morocco, while his cruisers explored a zone a little further to seaward in the direction of Cape St. Vincent ready to mislead, if need be, the enemy's cruisers by leading them in chase away from their admiral's route. Admiral Jauréguiberry, strong in the homogeneity and speed of his squadron B, had little to fear from his adversaries; he went straight to the rendezvous assigned for the weak Squadron C, everything depending on the judicious selection of that point so as to give C the best chance of escaping observation. As we have said, the plan was crowned with success. At 7 a. m. on the 5th, Squadron B was abreast Cape Villano and was standing south. The *Cassini* and the destroyers, having left Lisbon at 7 a. m., joined at 7 p. m. 32 miles south 72° west from Cape Mondego. During the night the squadron steamed in line ahead, natural order, at 600 m. distance, the destroyers acting as lookouts 2000 m. ahead of the flagship. The *Gambetta* alone kept her running lights lit, so as to seem to be one of the merchantmen, so numerous in those waters. At daylight Cape St. Vincent was rounded and the course was set directly for the rendezvous, which had been fixed at 50 miles off Larache, where B and C met without having seen a single enemy or even having had their wireless messages interfered with by him. It was then evident that Squadron A was cruising to seaward, and Admiral Jauréguiberry, wishing to find him so as to engage him with his now superior force, stood southwest, keeping his two groups not far apart, in line ahead, the 1st Division of B leading, then the division Manceron, and in the rear the 2d Division of B, followed by the cruisers of C. As on the previous evening the destroyers were deployed ahead. The crews were kept on the lookout for torpedoes all night, and no lights were allowed.

At daylight, nothing being in sight, the Admiral took a new

formation, intended to deceive the enemy into thinking the junction had not been effected. The *Desaix* led; 6 miles behind were the battleships of the division Manceron, with the *La Hire* and the *Du Chayla* on either flank, also at 6 miles distance; 6 miles further to the rear was Squadron B in line ahead. Thus disposed, the fleet stood to the north. At 1 p. m., the time for the end of the exercise having come without any encounter between the two adversaries, they stood separately for the general rendezvous. The concentration took place at 5.30 a. m. on the 8th.

Meanwhile the *Bombard* had had her bow somewhat injured by a sea, and started for Gibraltar, convoyed by the *Cassini* and the *Flamberge;* the *La Hire,* the *Forbin,* and the two squadrons of destroyers went also in order to coal.

The fleet then stood for the Mediterranean in the following order: 1st Squadron, *Suffren, Charlemagne, République, Saint Louis, Gaulois, Patrie.* 2d Squadron, *Léon Gambetta, Admiral Aube, Dupetit Thouars, Masséna, Jauréguiberry, Carnot.* Light Squadron (Rear Admiral Philibert) *Gloire, Gueydon, Jeanne d'Arc, Jules Ferry, Victor Hugo, Condé, Desaix, Du Chayla, Forbin, Cassini.*

In the afternoon and on the following day the fleet exercised at Fournier's tactics, with an imaginary enemy.

On the evening of the 9th the fleet was to be attacked by the 4th and 5th flotillas of torpedo-boats from Algiers and Oran. The 1st and 2d Squadrons, to take their assigned position, steamed to the east with all lights out, in line ahead, by squadrons, with 5 miles distance between squadrons, at a distance of 20 miles from the coast, the 1st squadron on the right and the destroyers guarding the right flank 5 miles from the 1st squadron. But the wind having been fresh from the E. N. E. during the day, the state of the sea prevented the torpedo-boats from following their program. At least not one of them was sighted.

On the morning of the 10th the fleet broke up, the divisions going to the various ports to which they had been assigned for celebrating the national holiday, July 14. The 2d division of the light squadron underwent an attack on the night of the 10th from the torpedo-boats of the defensive force of Bizerta, in accordance with the following program: The division (Krantz), composed of the armored cruisers *Jules Ferry, Victor Hugo,* and *Condé* without any destroyers, was to make a reconnaissance out-

side Bizerta, not going further than 30 miles from the coast and crossing the meridian of Cape Blanc not later than midnight. The torpedo-boats were to attack before 2 a. m., at which time hostilities were to cease. The following day the division was to go out of port again and be attacked by 2 submarines.

At 5 p. m. the two attacking divisions of the 3d flotilla (1st division, *Bourasque, Rafale,* and *Tramoutane;* 2d division, Nos. 361, 362, 363, and 364) left Bizerta accompanied by the *Dunois* and formed lines of blockade on the meridian of Cape Enghela, the 2d division covering the first 10 miles, the *Dunois* the second 10 miles, and the 1st division the 10 miles furthest to seaward. At 11 p. m. the cruisers came within sight of the torpedo boats of the 2d division. The latter manœuvered into a position parallel to the enemy's line and off their broadsides without being seen, and then torpedoed them one after the other. The night was very dark, slightly stormy, and so specially favorable for torpedo attack. At 3 a. m. the torpedo boats rejoined the *Dunois.*

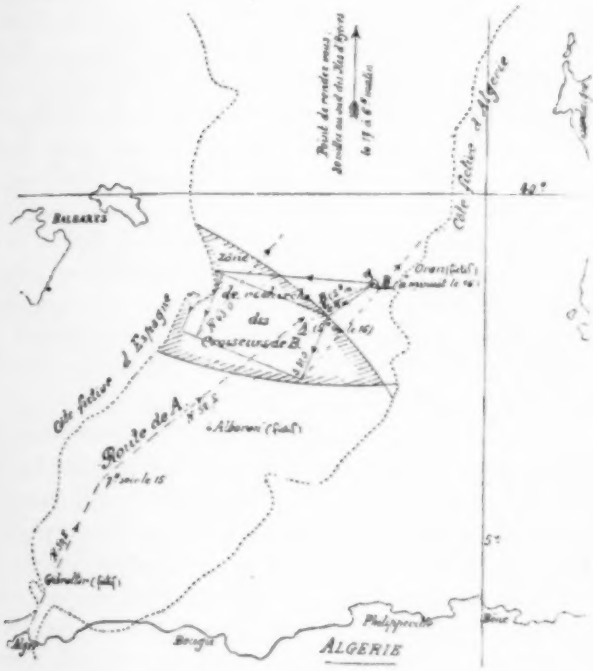
Early the next day the cruisers again put to sea and the submarines which had left the harbor and taken up their positions, attacked them.

The first phase of the manœuvers passed without any serious accident, despite the large number of vessels engaged. The *La Hire* injured a propeller on the Oran Jetty, and later wrecked her capstan at Gibraltar, where she had gone to coal; the *Carnot* had several injuries to her steering gear, and what is worse, lost a man overboard; the *Bombard* was slightly injured steaming into a heavy sea; and, finally, there was a fire on the *Gloire,* easily extinguished and not doing any damage.

2d Phase.—After a few days rest in the different Algerian ports, the squadrons were again brought together to carry out the second part of the manœuvers, the theme of which was as follows:

A Squadron B, concentrated at Oran, learning that a hostile Squadron A has passed Gibraltar at 1 p. m. heading east, gets under way to seek and fight it before it can reach the broad portion of the Mediterranean. In reality the respective positions of A and B corresponded to fictitious positions of Gibraltar and Oran, and the zone in which the action was to take place was also a fictitious one. This zone, to which the manœuvers were confined, may be traced on a chart by placing Gibraltar 20 miles north of Cape Matifou and turning the meridians about until

Oran comes about to a point, *a* (see the figure), in 39° 25′ N. latitude and 4° 10′ E. longitude. After midnight of July 15 to 16 (the hour when hostilities began) no ship was to enter the parts representing land. The conventions adopted were as follows: Speeds: A, 10 knots; B, battleships, 11 knots; cruisers, 15 knots. Relative strength proportional to the number of ships present, all battleships being considered of equal power and all cruisers the same. Any ship remaining for an hour within 3 miles of a



superior force to be regarded as destroyed. The exercise to end at 8 p. m. July 16, when the general rendezvous, for 6 a. m. July 17, was to be 20 miles south of the Isle d'Hyères.

Squadron A (Vice-Admiral Touchard).—Battleships *Suffren, Charlemagne, République, St. Louis, Gaulois, Patrie.* Armored cruiser: *Desaix.* Cruisers: *La Hire* and *Du Chayla.* Six destroyers.

Squadron B (Vice-Admiral Jauréguiberry).—Battleships: *Masséna, Bouvet, Jauréguiberry, Gambetta, Admiral Aube, Dupetit*

Thouars (the last three considered battleships during this exercise). Armored cruisers, *Gueydon, Gloire, Jeanne d'Arc, Jules Ferry, Condé, Victor Hugo.* Four destroyers. Cruiser, *Cassini.*

At midnight of the night of July 15 to 16 the various elements of Squadron B met off the fictitious port of Oran. The hour of A's departure being known, as well as his speed, and the obligation to be at the general rendezvous at the time fixed, it was easy for B to foresee within what limits the enemy would necessarily be at daylight of the 16th. These limits were, on the one hand the imaginary coast lines of Spain and Algeria, and, on the other, two arcs of circles, with Algiers and the point of rendezvous as centers, and with radii respectively equal to the maximum distance traversed, and remaining to be traversed at daylight. This fixed a comparatively narrow zone to guard, the difference of the radii of the two circles being only 40 miles.

At 5 a. m. of the 16th the *Gueydon, Jeanne d'Arc,* and *Cassini,* with the *Gloire,* scarcely having reached the N. E. limit of the zone to be guarded, sighted Squadron A in line ahead on a course N. 52° E. The other three armored cruisers, *Jules Ferry, Victor Hugo* and *Condé,* were at the N. W. of the same zone. The *Gloire* and the ships with her returned to the B Squadron, which soon, in its turn, sighted A.

The A Squadron was to have left Algiers so as to be under way off that port at 10.45 a. m. of the 15th, but, although beginning at 8 a. m., the movement was so retarded by the slow working of the capstans of the *République* and *Patrie,* that it was not finished till 11.30. At noon the squadron was assembled about 3 miles east of the fictitious Gibraltar, and Admiral Touchard set the course N. 30° E. At 5 p. m. the *Desaix,* coming from Bougie, joined. At 7 p. m. the course was changed to N. 52° E. so as to head directly for the initial position of the enemy (*a*) which A would reach, at 10 knots speed, about 6 the following morning. Admiral Touchard naturally thought that Admiral Jauréguiberry, with 7 cruisers and 4 destroyers to guard a zone only about 90 miles wide, would place his scouts on a line about east and west between the point *a* and the fictitious coast of Spain, and would station himself to the north, near the middle of the barrier so constituted, as to most quickly come into contact with the enemy wherever the latter might attempt to pass. Under these conditions, and with a knot-inferiority of speed, A had a very

small chance of escaping, whether he hugged the coast of Spain or that of Algeria. On the whole, then, the middle route was not sensibly more dangerous than the others. Accordingly Squadron A steamed N. 52° E., with all lights concealed after 2 a. m. At daylight, the enemy not being seen, which was a surprise, the *Desaix, La Hire,* and *Du Chayla* were sent to the westward to reconnoiter. About 5 a. m. the *Gloire* and then successively the *Gueydon, Jeanne d'Arc* and *Cassini,* were signaled, to the northward, and at 5.30 the B Squadron itself was in sight to the east. Desirous of using the day for tactical manœuvers instead of a sham battle, Admiral Touchard then signalled " End of the Exercise," " General Assembly," and soon the fleet, after the *Desaix, La Hire,* and *Du Chayla* had been recalled by wireless, was formed in column by squadrons.

The afternoon of the 16th was devoted to exercises with the new tactics.

During the night, navigation with lights covered, in view of an expected attack by the torpedo-boats from Corsica. The weather was a little thick, and the division flagship *Epée* alone succeeded in making an attack on the *Suffren;* the rest of the flotilla joined her too late and, daylight coming on, had to retreat from the squadron's torpedo-boats. It is to be noted that according to the special torpedo-boat tactics the flagship should lead the division to the attack but should not herself attack.

The same night an exercise in keeping in touch for the 2d and 3d Squadrons. The 2d Squadron had to escape from the cruisers during the night, and succeeded in doing so.

After further tactical exercises on the 17th, the fleet anchored at 7 p. m. in Salins d'Hyères.

On the 18th, similar exercises and then at 4 p. m. return to the anchorage of La Badine to prepare for a night attack from the 1st flotilla of torpedo-boats.

It would be a difficult, if not impossible task in time of war for a fleet to absolutely protect itself by its own resources in a roadstead so vast and so accessible to torpedo-boats as that of Salins. The experience, in time of peace, is none the less interesting.

The protection of the fleet consisted of destroyers on guard in each of the entrances; the search lights of the *La Hire,* moored between the Ile du Levant and Port Cros, the *Du Chayla* beneath Brégançon, and the *Cassini* beneath Porquerolles; and a

boom 1800 meters long extending from the shore towards the east. The Admiral ordered the search lights of the large ships not to be used for picking up attacking boats but only for illuminating those which had already been discovered.

At 4 p. m. the fleet moored in three parallel lines extending N. E. to S. W. Establishing the boom, and not very satisfactorily, took until 10 p. m. The moon set towards midnight; five minutes later three torpedo-boats succeeded in getting within 200 meters of the *Masséna* and *Jauréguiberry*, which were at the end of the inner line, without being discovered. At 12.15 and at 2 a. m. a second and a third attack against the same ships succeeded. About 2 a. m. the *Du Chayla* was also attacked by two torpedo-boats. Then the time came for the end of the exercise. On the whole the torpedo-boats were successful.

On July 19th the fleet, still in three squadrons, put to sea at 8.30 a. m., and stood south at 11. The enemy, represented by the *Desaix, Du Chayla, Cassini, La Hire,* and six destroyers, was signalled, bearing S. 45° E. The fleet, which was in line ahead by squadrons, passed to battle formation in a single line ahead; to this end the 1st Squadron, in order to occupy the center of the line, stopped, the 2d took the lead, and the 3d closed up on the first, a movement which took over half an hour and during which the ships—especially of the 1st and 2d Squadrons—could not help masking each others fire. At 11.30, the enemy retreating, the fleet formed line of bearing and then line abreast, turning to the left and always following the enemy's movements. About 2 p. m., by signal from the Admiral, the enemy separated into two divisions, which attempted an enveloping movement against the fleet, which latter was divided to meet them.

On July 20 a continuation of the tactical exercises, but without use of the compass. That evening return to Toulon, and the end of the second phase of the manœuvers.

3d Phase.—These exercises were particularly important from the fact that they were witnessed by the "Commission on the Revision of Naval Tactics." The program proposed by Admiral Touchard had the following objectives:

1st. Prompt formation of line of battle from day and night cruising formations.

2d. Maintenance of the line of battle in movements executed with limited signaling (for example, a simple signal *confirmative*

of the intended movement by the commander-in-chief or the squadron commander), and even without signal, first with use of the compass and then without it, against an imaginary enemy.[2]

3d. Action against an enemy.

For this last part the enemy would be relatively free from conditions; his complete subordination would take most of the interest from the exercise, while his complete independence might be somewhat dangerous.

Under these conditions the program of the five days of manœuvers was as follows:

1st day. Formation of line of battle from cruising formations. Manœuvers of the divisional groups with limited signalling and the use of the compass. (Enemy imaginary.)

2d day. 1° continuation of exercises of previous evening. 2° manœuvers of the divisional groups with compass, but without signals, against an enemy.

3d day. Same exercises as previous day, but without compass. Action against an enemy with manœuvers against envelopment.

4th day. Conduct of an action, in formation No. 1, with use of the compass and a minimum of signalling, the enemy being comparatively freed from conditions.

5th day. At the disposition of the Commission.

As in the preparatory exercises, the enemy was represented by the *Desaix, Du Chayla, Cassini, La Hire,* and 6 destroyers, under Captain Moreau, of the *Desaix*. The speed of the enemy group was supposed to be one knot greater than that of the fleet. Captain Moreau was directed to manœuver and fight in line at such variable distances as to make his line of about the same length as his opponent's; his line was allowed to execute at will countermarches and simultaneous turns of 4 points without signal, and simultaneous movement of 8 points on signal; generally speaking, he was not to approach nearer than 2000 meters to the fleet; in the first exercises, when he was sighted, he was to indicate by his course the side from which he intended to engage but in the later ones he was to leave the fleet in ignorance as to this; he was either to manœuver at a maximum speed equal to that of the fleet, or, if he used higher speed, he was to endeavor to cap the fleet and so force it to turn away.

[2]The interdiction of the use of the compass did not apply to compasses in protected positions, notably in the central station, whose indications could be transmitted at any time to the conning tower.

For this third and last phase of the manœuvers the reserve division of the Mediterranean Squadron was added to the fleet, which was then constituted as follows:

1st Squadron (Vice-Admiral Touchard).—*Suffren, Charlemagne, République, Saint Louis, Gaulois, Patrie.*

2d Squadron (Vice-Admiral Jauréguiberry).—*Léon Gambetta, Admiral Aube, Dupetit Thouars, Masséna, Jauréguiberry, Carnot.*

3d Squadron (R. A. Germinet).—*Brennus, Hoche, Charles Martel, Gloire, Gueydon, Jeanne d' Arc.*

Light Division (R. A. Krantz).—*Jules Ferry, Victor Hugo, Condé.*

Enemy (Captain Moreau).—*Desaix, Du Chayla, La Hire, Cassini,* and 6 destroyers.

It had been thought that for the first exercises on the program an imaginary enemy would suffice, but Vice-Admiral Caillard, president of the tactical commission, insisted upon the enemy always being represented. Under this condition the desire to shorten the dead time between successive formations might result in opposing a line in process of formation to one which, having shorter distances to cover, was already formed. It was necessary, then, for a proper appreciation of results, not to allow the enemy to execute his manœuvers so rapidly as to profit from the fleet's being caught in the act of forming.

On July 23 the fleet stood out of Toulon about 8 a. m. The enemy led so as to reach his fixed initial position. The fleet formed, heading south, in columns by squadrons, in cruising order, the 1st Squadron in the middle, the 2d on the right, and the light division astern of the 3d Squadron.

Two exercises were arranged for: In the first the fleet had the initiative, the enemy merely responding to its movements by opposing ones; in the second the enemy manœuvered first and the fleet made the appropriate responses.

The enemy having been made out at 8000 meters to the south, at 10 a. m., the Admiral ordered the formation of line abreast: this is the regular order of battle in line abreast, in triangles by divisions, the 1st Squadron in the center, the light division to the left and rear. This movement was very correctly done.

Then the formation was changed from line abreast to line ahead: the group commanders forming line ahead by a simultaneous movement of 90° right, and ships 2 and 3 of each group, placed in

echelons, forming two other parallel lines on the inner side of the first line. Here there was some confusion, two battleships trying to take position to the left of their chief of group instead of to his right, but the error was soon corrected.

There was no special interest in the succeeding formations: line of bearing, right in front; line abreast; line ahead; return to line abreast; each of these movements corresponding to a similar one on the part of the enemy.

At 11 a. m., as arranged, the enemy, who is in line ahead, steering west, turned by head of column to the south and increased his speed to 14 knots, in order to take up position for the following exercise, which comprised passing from cruising columns to order of battle in line abreast, in a direction oblique to, instead of perpendicular to the course. In the meantime the fleet reformed in cruising order, in columns by squadrons, heading south. At noon, the enemy being on the starboard bow, the Admiral signaled to form in order of battle, line abreast, turning to the left. The fleet (this formation being taken) thus found itself heading S. 22° W. on a line of bearing S. 68° E.

At 12.15, having turned to the left into line ahead, the fleet then turned by head of column to the east, the enemy having, by order, approached within 4000 meters and holding a course parallel to that of the fleet.

At 2 p. m. the exercise is renewed. This time the enemy is sighted on the port bow, and the fleet executes a series of movements similar but symetrically opposite to the preceding ones.

The first day's manœuvers, having lasted longer than was anticipated, were terminated by anchoring in Toulon roadstead by night, an operation of some delicacy with a large fleet, but which was well executed.

On July 24th, as before, the fleet stood out of Toulon and formed columns of squadrons heading south. At 9.15 a. m. the Admiral signaled to form line of battle in line ahead, the enemy being to starboard. The 1st Squadron being in the center and the 2d on the right, the 3d Squadron went ahead at full speed and took position at the head of the line. It took about 30 minutes from the signal of execution till the formation was correctly taken.

At 10.45 a. m. movement by head of column, 2 points left, and from then on manœuvers without compass.

At 10.45 a. m. turn to the right on line of bearing, left in front;

then successively to advance in line abreast; to advance on line of bearing, right in front; to advance on line of bearing, left in front; and finally to advance in line abreast.

The enemy, meanwhile, to the south, follows changing courses corresponding to those of the fleet.

At 11.45 cruising formation is resumed, heading N. 68° W. In the afternoon, repetition of the morning's work—passage from cruising columns to line of battle in line ahead, advances on lines of bearing and in line abreast—completed by ordinary cruising formation in columns; manœuvers begun, for greater safety, at 6700 meters from the enemy instead of at 3000 meters, the maximum distance fixed in the tactics for beginning it. Nothing worth mention, except the uneasiness and hesitations, caused by the continual changes of guide, necessitated by the tactical rules, in the successive evolutions.

On July 25, after leaving port, the fleet took the formation for foggy weather, in line ahead, with the squadrons in their numerical order, course south, then S. 70° E. It was arranged that the enemy should await the fleet in a fixed position in the offing, and that he should be supposed to take it by surprise at 6000 meters distance—despite the supposed fog. On the other hand the orders given to Captain Moreau prescribed that when the enemy made out the fleet's movement of deployment, that is to say, the 2d Squadron taking up its position behind the 1st Squadron, already in line—he should reverse his course by a simultaneous turn, but at very slow speed, so as not to approach too near to the fleet, which would itself manœuver to re-establish the action. Actually, the enemy being signaled to the south, the fleet took the formation of advance in line abreast, then turned into line ahead in response to a corresponding movement of its antagonist.

The exercises continued by a manœuver against envelopment, the 2d Squadron being detached to engage the enemy's left while the latter's right was engaged with the 1st and 3d Squadrons. Soon, however, the 2d Squadron found itself out of fighting range, and the Admiral signaled to it to regain its position in the line. At noon cruising formation again.

This day began a new phase of the exercises, the enemy being given relative freedom of choice of movements. At 2.45 p. m. the group *Desaix*, which is far off, is signaled to take position on the bow of the fleet, which is in line ahead. The fleet then turns

4 points to the left simultaneously, heading for the enemy, and hastily assumes battle formation in line abreast. Then passes to line ahead by turning simultaneously to the right, in imitation of the enemy; then, the enemy threatening to envelope its head, the fleet turns to the right to parry this manœuver. It is then late, and the fleet returns to Toulon.

On July 26 the enemy stood out of port at 6.30 a. m.; the fleet not till 8. There was no official program, the two groups being free to manœuver at will under condition of not approaching nearer than 2000 meters to each other.

At 9.45 the fleet cruising in columns by squadrons, course south, at 7 knots speed, the enemy is sighted bearing S. 45° E.; he is in line ahead, steering about N. 45° W. At once the fleet turns 4 points to the left; then takes the battle formation for approach in line abreast. The enemy, still in line ahead, goes head of column 90° right. The fleet immediately turns to the left into line ahead. The enemy turns back to the left, and the fleet forms on a line of bearing, left in front; the enemy keeps on turning to the left; the fleet changes its line of bearing 90°, forming on a line of bearing with the right in front, and finally, after turning 45° to the right, finds itself advancing in line ahead with the enemy on its port hand.

Captain Moreau has made only simple movements by head of column in line ahead or simultaneous movements; the fleet, in order to follow him, has had to manœuver continually, paying more attention to the rapid assumption of nice formations than to the efficient use of its ordnance; meanwhile the breeze has freshened, the sea is getting up, and at 1 p. m. the Admiral orders the destroyers, the *La Hire*, and the *Cassini* to return to Toulon, replacing them in the enemy's line by the *Jules Ferry*, *Victor Hugo*, and *Condé*, whose rôle as the light division of the fleet has been thus far a very restricted one.

For the afternoon's exercise the orders of the commander-in-chief to the enemy are to proceed out of sight of the fleet; then to attack from the rear, the maximum speeds of the two groups being the same, 12 knots.

At 1.30 the fleet was cruising in columns on a course N. 68° W., when the enemy was sighted bearing S. 75° E., that is, astern and slightly to starboard. The fleet at once deploys and advances in line abreast, heading N. 15° E. But this very long movement,

interfered with by the wind and swell, is not completed until already the enemy's line, with broadsides bearing, arrives abreast of the scarcely formed 1st and 2d Squadrons, while the 3d Squadron is masked by them, not yet being in the line. The position appears so disadvantageous to the Admiral that, without further delay, he signals the formation in line ahead.

The rest of the exercises, advances first with the right and then the left in front and in line ahead with the enemy to port, in response to the latter's ships about, take place without incidents, ending at 3.30. At 5 p. m. the fleet returns to its anchorage.

The Tactical Commission decided not to have a fifth day of manœuvering, having doubtless collected enough data during the preceding days for prolonged consideration. How the Commission was impressed and what its conclusions will be cannot be foretold, but one thing is certain, and that is that there is practical unanimity of opinion among the officers who took part in the exercises in condemnation of the principle of deep formations and of manœuvering a fleet as a unit (en masse).

The Fleet Target Practices of July 29-30.—In order to have the same target practice participated in by homogeneous groups accustomed to holding target practices together, the arrangement of squadrons for these last exercises was as follows:

1st Squadron: Divisions *Suffren* and *Saint Louis.*

2d Squadron: Divisions *Brennus* and *Masséna.*

3d Squadron: Divisions *Gambetta* and *Gloire.*

Light Squadron: Division *Jules Ferry, Desaix* and *Du Chayla.*

A fleet order set forth the object of the exercises and fixed their details; the following were its main features:

The firing will be by division, the principal object of the exercise being to indicate to what extent formations of divisional groups lend themselves to fire control.

Two targets will be moored in the roadstead of Salins, each formed of two large targets completed at each end by two wing targets. The length of each entire target is 64 meters, the height of the framework being 8 meters and that of the masts 20 meters.

The observers will be stationed at suitable places on shore. The squadrons may choose either of two routes, as determined by the personal convenience of their commanders-in-chief and the conditions of visibility of the targets. On each of these routes there is one change of course of 10°.

The distance to the targets within the firing limits varies from 4000 to 6500 meters.

Each squadron will be in line ahead with a distance of 4000 meters between divisions so that the two divisional groups may not simultaneously fire at the same target. All the firing will be done on a single run and the speed will be from 8 to 10 knots.

Of the two objects stated by the fleet order—to test the efficiency of the fire of the triangular group and to observe the effects of the simultaneous fire of three ships upon a single target, the first can hardly be said to have any importance, since, the course being straight, if the ships maintained their positions, each would fire exactly the same as if it were alone.

All the firings took place in clear weather with a perfectly smooth sea, and on the second day the sky was cloudy, giving an excellent light for sighting.

The targets did not seem to be much damaged, and considering that each of them withstood for an average period of 20 minutes the fire of a dozen battleships, it may well be said that the fire was not very accurate; it was well regulated in the sense that the targets were constantly surrounded by the points of fall, but the zone of dispersion was very great and the density of the fire in each part of that zone very small. The control of the fire appears to have been good; moreover, at the moderate ranges, with excellent light, good visibility of the targets, and a flat calm, the gun-pointer's errors could only have been insignificant.

Consequently the excessive dispersion must be attributed to the material and above all to the irregularity of the powder.

A still graver fault was that a considerable proportion of the projectiles burst in flight without ever reaching the targets, thus further diminishing the percentage of hits.

The practice was with full charges, as usual, but with loaded shell—cast iron shell loaded with black powder, the regular allowance for the 4th quarter. In previous years, especially in 1906, some premature bursts of shell had been noted, but they were from the 6.5-inch guns. This time it is the 12-inch which burst prematurely.

On the *Carnot* there were 3 prematures out of 5 shots from the 12-inch, 1 out of 6 from the 10.8-inch. On the *République,* 1 premature from the 12-inch and 16 from the 6.5-inch. On the *Suffren* 6 out of 12 from the 12-inch and several from the 6.5-inch. On the *Saint Louis* 11 prematures out of 12 shots from the 12-inch. And so with the other ships.

These are facts; our shells burst 50 meters from the broadside, with thick smoke, fragments scattering over the water for a distance of 500 to 600 meters. With the 900 m. s. initial velocities of our guns, happily there was nothing to fear from fragments to which the black powder bursting charges gave velocities of only 500 or 600 m. s., but what might not have happened with melinite shell?

Still the gunners showed good progress and the excellent execution of the broadsides of all the ships is worthy of notice. The rapidity of fire was also very good; in most of the 12-inch gun turrets the average was better than in previous years, and on a number of ships the rate of fire was attained of 8 shots in 2 minutes from the 6.5-inch guns.

Further information regarding the firing exercises follows:

The *Suffren* and *République*, firing together at the first target, made 13 per cent of hits with their medium and 55 per cent with their main battery guns. (The *République* fired 5 and the *Suffren* 6 12-inch shots; there were 2 prematures; of the 9 effective shots, five hit the target. The *Charlemagne* did not fire at the first target.)

At the second target the *Charlemagne* also fired; the medium guns made 17 per cent and the big guns 18 per cent of hits.

The 2d division did better than the 1st. The best percentage was obtained by the 2d division of the Northern Squadron (*Gloire*); taking the general average for the two targets there was 31 per cent of hits.

The *Gambetta* had 3 prematures with her 6.5-inch guns and on the *République* 18 per cent of the shell fired burst prematurely.

Many ordnance officers attribute the prematures to excessive pressures; the fuses used were mostly of an old pattern considered barely safe when fired with present service velocities, and too sensitive to withstand any considerable increase of acceleration in the guns. The fact that shell similar to those used at this practice, but blind loaded, have been repeatedly fired without rupture seems to definitely dispose of the theory that the shell walls were too weak.

As soon as practicable further firing tests are to be made to settle beyond question the causes of the defects in ordnance material developed in the fleet target practice; meanwhile an order has been issued to immediately replace on shipboard all cast iron shell loaded with black powder and fitted with fuses of old pattern.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

A BRIEF DESCRIPTION OF THE FUNCTIONS AND OPERATION OF AN EXPERIMENTAL MODEL BASIN.[1]

By Naval Constructor R. H. M. Robinson, U. S. Navy.

The original and fundamental idea in the establishment of experimental basins, or, as they are otherwise called, "model tanks," was to assist in the determination of the resistance of ship-shaped forms at various speeds of propulsion, and thence the deduction of the power required to drive a given form at a given speed, and also the most desirable form for any given speed.

Their functions have been extended to include experiments with propellers, tending toward the solution of the problem of the best form, dimensions, and locations of propellers, and to include other experiments of kindred nature in connection with problems of ship construction and propulsion.

Originally, the underwater forms of vessels were determined by experience with full-sized ships, or by considering, by looks and touch, the shape of a small wooden model.

Some experiments on the resistances of various surfaces were made in the eighteenth century by several naval architects and others interested in the subject; notable among these was Colonel Beaufoy, the results of whose experiments were published in 1834.

In 1874, in a paper presented to the British Institution of Naval Architects, Mr. William Froude propounded what is now

[1] For the greater part of the description of the U. S. Model Basin and the apparatus, contained herein, I am indebted to the Society of Naval Architects and Marine Engineers and to Naval Constructor D. W. Taylor, U. S. N., with whose permission they have been used.—R. H. M. R.

known as " Froude's Law," or the " Law of Comparison," which is a special application of the law of similitude, first propounded by Newton.

The whole usefulness of model-basin experiments is due to the truth of this law, which permits accurate and exhaustive experiments at reasonable cost, and the accurate determination of characteristics of a given model prior to building, which in turn permits ready determination of the horsepower necessary to give any required speed in the full-sized ship.

The law, which was deduced by Mr. Froude, with the aid of the British admiralty, from consideration of results of experiments with the British ship *Greyhound* and with models towed in the basin at Torquay, may be expressed in the following words:

Eliminating the resistance due to skin friction, if a ship be D times the dimensions of a model of similar form, and if at the speeds V_1, V_2, V_3, the measured resistances of the model are R_1, R_2, R_3, then for speeds $\sqrt{D}V_1$, $\sqrt{D}V_2$, $\sqrt{D}V_3$, of the ship, the resistance will be D^3R_1, D^3R_2, D^3R_3.

The speeds V_1, V_2, V_3 for the model and $\sqrt{D}V_1$, $\sqrt{D}V_2$, $\sqrt{D}V_3$ for the ship are termed corresponding speeds.

It was early found that the skin friction did not follow this law.

The three elements of ship's resistance have been determined to be, (1) skin friction, (2) eddy resistance, (3) wave making resistance.

The total resistance, minus the skin friction, is termed the residuary resistance.

The skin friction of a ship has been found by many experiments to be practically the same as that of a plane surface of the same nature, area, and length in the direction of motion as the curved wetted surface of the ship.

The skin resistance of a ship may then be expressed as a formula:

$$R_s = fSV^n.$$

where R_s = skin resistance.

S = wetted surface in sq. ft.

V = the speed in knots.

f, n = semi-constants changing somewhat with the nature and dimensions of the surface and determined by experiment only.

Tables of these constants, as separately determined by Mr. R. E. Froude and Dr. Tideman, are given in Taylor's "Resistance and Propulsion of Ships."

The original experimental basin, as stated, was developed by Mr. Froude and was located at Torquay, being established in the seventies. (The British experimental station has since been removed to Haslar. See below). Since that time a number of experimental stations have been established, both by private firms and by governments. A partial list of such stations follows:

EXPERIMENTAL MODEL STATIONS.

Date.	Location.	Length.	Breadth.	Draught.
1884	Leven Shipyard, Dumbarton	300	20	8.8
1886	Haslar	400	20	9.2
1889	Spezia	479	19.7	9.8
1900	North German Lloyd S. S. Co., Bremerhaven	538	19.7	10.0
1903	Charlottenburg	528	34.5	11.5
1904	John Brown & Co., Clydebank	490	32.0	10.0
1899	U. S. Government, Washington, D. C.	470	42.8	14.8
1905	University of Michigan, Ann Arbor	300	22	10
1907	French Government	(Just completed.)		

All these vary in matters of constructional detail, but all aim at the same results, and the variations are due in most part to differences of local conditions or considerations of expense.

Probably one of the most complete is the U. S. Government basin located at the U. S. Navy Yard, Washington, D. C., and operated under the Bureau of Construction and Repair of the Navy. The design and installation of this basin was under the direction of that able officer, Naval Constructor D. W. Taylor, U. S. N., who has also been in charge of the experimental work since the opening of the basin in 1900.

The basin holds about a million gallons of water. It is filled from the city supply for Washington.

Before reaching the basin the water is treated with a small quantity of alum, which removes any mud present, and is then clarified by passing through a sand filter.

A small stream is kept constantly running through the filter to freshen the water after filling, and to make up for leakage and waste.

The basin can be pumped dry in about four hours by an electrically-driven centrifugal pump. Two other electrically-driven

pumps are fitted, a four-inch centrifugal pump connected with troughs on each side of the basin just at the surface, by which the water can be "scummed," and a small plunger pump used for drainage and piped to take the water from inside or outside the basin as desired.

The building is heated by hot air. The temperature is generally kept slightly higher than is usual for an ordinary living or working room. Otherwise the operators of the traveling carriage are liable to discomfort from their constant motion to and fro through the damp air.

Steel troughs about 12 inches square in sections are located on each side and just below the usual working level of the water. They act as absorbers of wave disturbances and cause them to die away rapidly. In addition there is at one end of the basin a "wave-breaker," consisting of a large number of square strips of wood set vertically at varying distances apart. These, with the side troughs, result in reducing any wave motion set up by a run of a model into minute ripples by the time eddies and currents due to the passage of the model, have been dissipated. Without wave-breaking appliances, running trials at high speeds would be a long operation as long waits between runs would be necessary to allow the waves to subside.

The apparatus for measuring the resistance of models is carried on the traveling carriage which spans the basin as shown in Plate I. This carriage weighs about 70,000 pounds, and hence has sufficient inertia to resist sudden variations of speed.

The carriage is driven by four motors, one on each corner. The speed is controlled on the Ward-Leonard system. Current from an "exciter" generator at 110 volts keeps constant excitation in the field coils of the motors and current from the same exciter passes through the controlling rheostats on the carriage and also around the field coils of the main generator.

The main generator runs at constant speed controlled by a governor which limits variation of speed within 1½ per cent from no load to full load. The generator armature is in series with the motor armature, so that all the current developed at the generator passes through the motors, the voltage at the generators varying according to the amount of excitation of the generator fields which is controlled from the carriage.

The four motors are so arranged that they may be connected all in series, or two and two in series, the pairs being parallel.

PLATE I.

The maximum generator voltage is 250, and as there are two generators which can be arranged in series, the maximum available voltage is 500. The motors are geared together, two and two across the carriage, and also geared down to the main driving wheels. In addition, the forward pair of motors has back gearing for low speeds. For many experiments one generator only is required, the motors being arranged all four in series for speeds ranging from ½ knot to about 6½ knots, and two and two in series parallel for speeds from 6½ knots to about 12½ knots.

The maximum speed at which the carriage can run is about 20 knots, developed in a run of about 200 feet.

With such a heavy mass moving at this speed in a confined space, very careful provision is required for stopping.

With the Ward-Leonard system a powerful electrical braking effect is obtained from the driving motors, through the back current generated when the exciter current around the generator fields is shut off or reversed. This enables the carriage to be stopped more rapidly than it is started. This method of stopping is not relied upon solely, since it fails if the circuit is broken either accidentally or by the automatic circuit breakers in case of an overload. This method also necessitates proper manipulation on the part of the person operating the carriage. At least one method of braking to stop the carriage in the minimum possible distance was desirable, independent of the electric current, and not requiring manipulation by the operator. Wheel brakes could not be used, as they would cause objectionable wear on the wheels of the springless carriage, and would stop it no more rapidly than the electric brake supplied by the Ward-Leonard system (it may be noted that from time to time the wheels require truing up to insure accurate measurements). Friction brakes closed by hydraulic pressure were therefore fitted. These are fitted at the north end of the basin in the form of a pair of iron strips on each side, securely anchored at one end to the main walls of the building, and pressed together by hydraulic cylinders. They are 15/16 inch apart when the pressure is on and 1-1/16 inches apart when it is off, being pulled apart by springs when the pressure is released. A strip of iron about 1 inch thick and 12 feet long is securely bolted to each forward corner of the carriage, and is adjusted to enter without shock

the space between the stationary strips, and by friction against them bring the carriage to rest. Hydraulic pressure is obtained from a small electric pressure pump, and an accumulator is fitted, through which the pressure can be varied from 100 pounds to 600 pounds per square inch. Two gauges at the south end of the basin indicate the pressure in the hydraulic cylinders, so that the operators may know before starting a run that the friction brake has pressure on. The strips are kept lubricated in order to avoid seizing or violent shock.

In addition to these, there is an emergency brake, which takes hold of the carriage if it should get through the friction brake without being arrested. This consists of a taper piston rod passing through a round hole in the cylinder head, which it gradually closes as it moves; the principle is the same as the hydraulic recoil brakes for heavy guns. The hydraulic cylinder is below the water level when the basin is full, and when this is the case the emergency brake is always ready. The parts of this brake are bolted in place by fastenings which will be broken in case the brake comes into action, but up to the present time this has never happened.

MODELS.

Paraffine, which is largely used for models in experimental basins abroad, has many advantages, but cannot be used in Washington as it will not stand the summer temperature without too much softening.

As compared with paraffine as a material for the construction of models, white pine has the following advantages and disadvantage:

ADVANTAGES.

1. Wood retains its shape better during changes in weather.
2. Wood is many times stronger.

DISADVANTAGES.

1. Wood is harder and more expensive to fashion.
2. Wooden models are harder to keep tight.
3. Wooden models are harder to give a uniform surface.

The first and second objections have been overcome by the adoption of special machinery designed by Naval Constructor Taylor, and the third by using a special varnish to finish the models, which gives a surface practically uniform.

Owing to the greater strength of wood it is feasible to make models 20 feet long, and the sectional area of the basin is such that these models may be run with no greater interference from the size of the basin than 12-foot models in the smaller foreign basins.

The advantages of this size, as compared with the 12-foot size, in determining resistance, are great. It is found that for the 20-foot models of many U. S. naval vessels, the resistance at the speeds corresponding to the actual maximum speeds of the vessels, is below 40 pounds. With 12-foot models the resistances would have been below 9 pounds. A 20-foot model is 1/1728 the displacement of a 240-foot vessel, and 1/13,824 that of a 480-foot ship.

For a 12-foot model these figures are 1/8000 and 1/64,000, respectively.

With the large model, resistance is measured more easily to a given percentage of accuracy, and the gap between models and ships to be bridged by the Law of Comparison is not so great.

It is the usual practice at the U. S. model basin in the case of models of men-of-war to determine five resistance curves, each extending somewhat beyond the speed corresponding to the maximum speed of the vessel. These curves are as follows:

No. 1. With the model at a displacement corresponding to the designed normal displacement of the ship and at the designed trim of the ship.

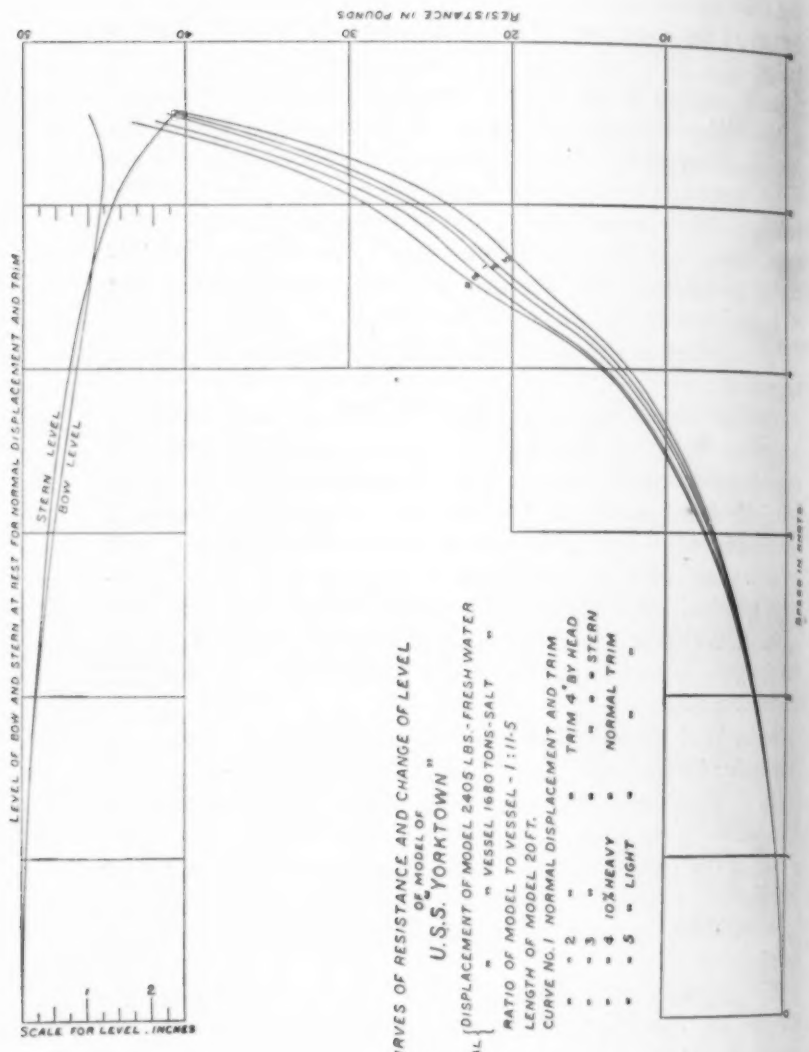
No. 2. With the model as in No. 1, except the trim is changed four inches by the head.

No. 3. With the model as in No. 1, except the trim is changed four inches by the stern.

No. 4. With the model as in No. 1, except that it is 10 per cent lighter.

No. 5. With the model as in No. 1, except that it is 10 per cent heavier.

Plate II shows these five curves for a model representing the *Yorktown*. The displacement of this vessel corresponding is 1680 tons and the designed trim 2 feet 1½ inches by the stern. The maximum speed of the *Yorktown*, when tried at 1680 tons, was 16.7 knots. The corresponding speed of the model is 4.93 knots. The curves of Plate II are carried higher in proportion to the designed speed of the vessel than is necessary.


RESISTANCE IN POUNDS
50
40
30
20
10
LEVEL OF BOW AND STERN AT REST FOR NORMAL DISPLACEMENT AND TRIM
STERN LEVEL
BOW LEVEL
SCALE FOR LEVEL - INCHES
CURVES OF RESISTANCE AND CHANGE OF LEVEL
OF MODEL OF
U.S.S. YORKTOWN
NORMAL { DISPLACEMENT OF MODEL 2405 LBS. - FRESH WATER
" " VESSEL 1680 TONS - SALT "
RATIO OF MODEL TO VESSEL - 1 : 11.5
LENGTH OF MODEL 20 FT.
CURVE NO. 1 NORMAL DISPLACEMENT AND TRIM
" " 2 " " " TRIM 4" BY HEAD
" " 3 " " " " " STERN
" " 4 10% HEAVY " NORMAL TRIM
" " 5 " LIGHT " " "

SPEED IN KNOTS

PLATE II.

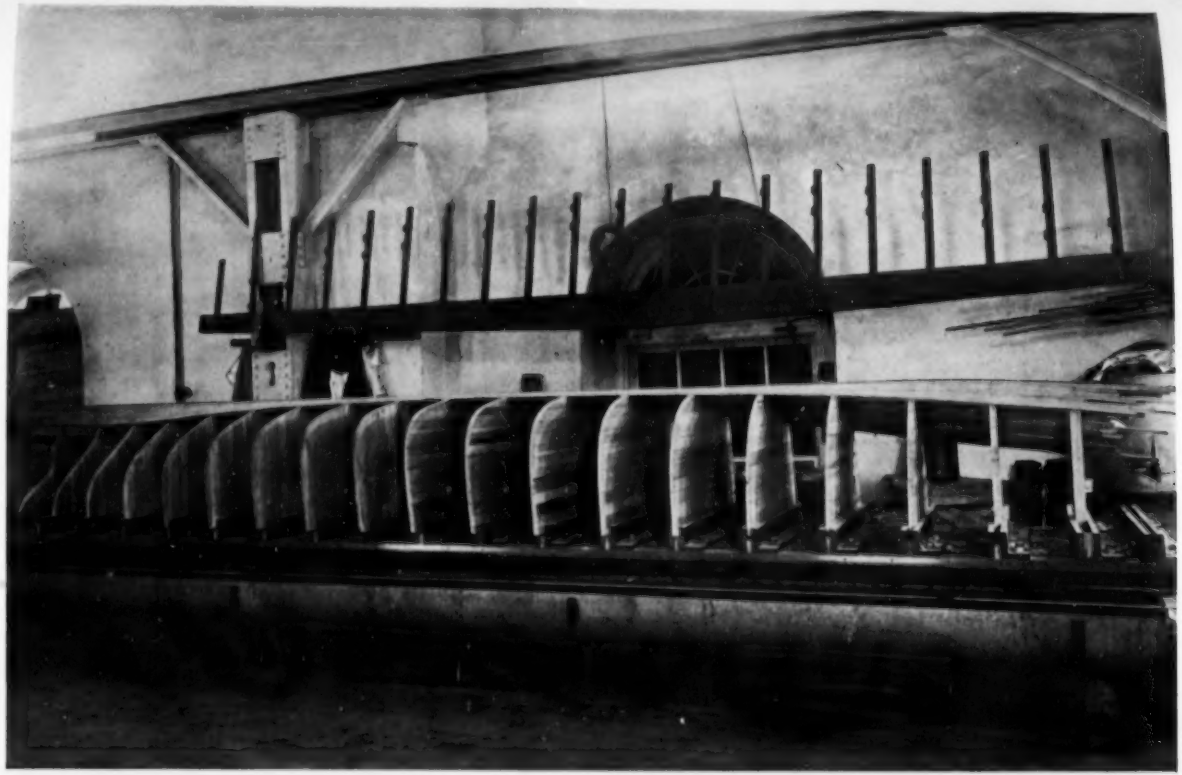


PLATE III.

The speeds of 20-foot models corresponding to the maximum speeds of some of our battleships are given below:

Battleship.	Length.	Maximum.	Corresponding speed of 20-foot model.
Oregon class	348	16.8 trial	4.03
Iowa class	360	17.1 "	4.03
Kentucky and *Alabama* classes	368	17.1 "	3.99
Maine class	388	18	4.09
Georgia class	435	19	4.07

Plate I shows the carriage in operation, towing a model of the battleships of the *Georgia* class.

PREPARATION OF MODELS.

Models are as far as practicable made of the standard mean immersed length of 20 feet. The length over all is usually somewhat greater, The model-making apparatus is designed with the idea of working from a body plan. Having a correct body plan upon a certain scale, sections of a 20-foot model corresponding to the sections in the body plan are first determined, using an eidograph, and with the usual scales for drawings and sizes of vessels, it nearly always involves enlargement. The eidograph works upon a table covered with a sheet of glass.

Having properly adjusted the length of arms by means of the scales provided, the pointer on the short arm is run around the sections of the body plan, the pencil on the long arm describing the sections desired upon pieces of paper. These paper sections are used as patterns for use in cutting out the wooden sections for the former model. These are clamped in their proper relative positions upon an iron table and a skin of round strips of wood nailed securely to them. Plate III shows this skin partly in place. This completes the " former model," as it is called, except that plaster is later applied as described below. Its ends are not made to accurately represent the vessel, as it has been found more desirable to rough finish only from the former the ends of the final model and finally finish them by hand.

While the former model is building, a wooden block is built up of white pine planks about 2 inches thick, sawed hollow and glued together hot under heavy hydraulic pressure. This block is so proportioned that when the finished model is cut from it, the wood will be left amply thick, generally not less than about 2 inches. Additional thickness is not especially avoided, as the

models require ballast in every case. The former model and its corresponding block are now secured in the model-cutting machine, the former model being below. As may be seen from Plate IV, the roller below rolls over the former model, and the saw above, driven at high speed, is constrained by the balanced link work to move exactly above and at a uniform distance from it. The sizes are so arranged that the saw does not cut within one-eighth of an inch of the intended finished surface of the model. There are two traversing cutter heads, one on each side. Each is traversed (by an electric motor) three-quarters of an inch or so at a time and then a saw cut made. Then the superfluous wood is knocked off, the interstices between the battens of the former model plastered with plaster of Paris to give a smooth surface, and a rotary cutter substituted for the saw, with a corresponding roller. This cutter rough-finishes the model to very near its exact size. The model is then removed from the machine and finished by hand, the ends, which are left quite rough, being also shaped by hand from paper patterns or light wooden templates obtained from the lines. Sanded disks, driven at high speed by an electric motor, are used to finish. The models are carefully painted, inside and out, and a standard varnish finally applied to the outside to get a uniform surface.

Before being taken to the basin, the models are carefully measured.

From the results of measurement, a body plan is drawn and compared with the original lines to insure that the model accurately represents the ship. All calculations at the model basin are made from actual lines of the models.

The tops of the completed models are parallel to their designed water lines, and with the level straight-edges fitted in the south end of the basin, it is easy to determine the exact trim of the model when afloat.

All trials are run by weight and draught is used only as a rough check. Before beginning a trial a model is suspended to one of the cranes on the carriage, and weighed. It is then ballasted until its weight in fresh water corresponds to the desired displacement of the ship which it represents. After a trial the model is weighed again for checking after the ballast has been removed. Models are handled by electric cranes, one on the forward side, the other on the after side of the carriage. The models are stowed on the galleries on each side of the basin.

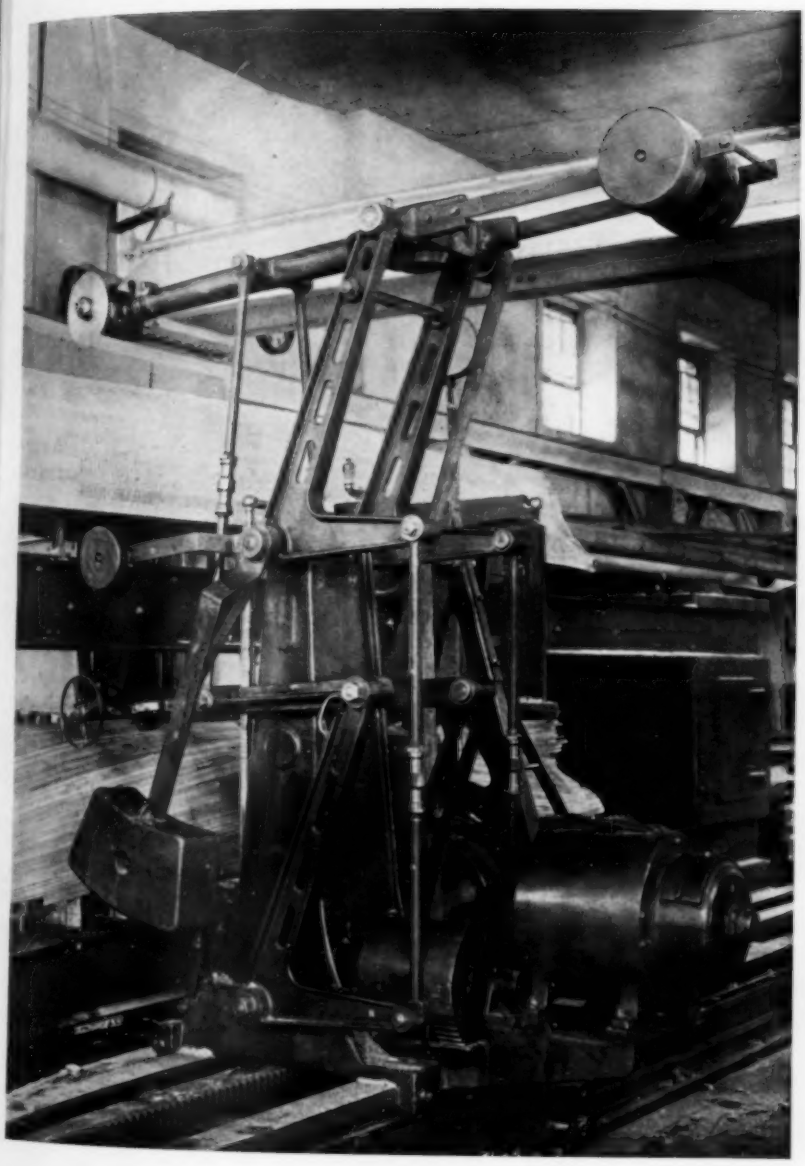


PLATE IV.

The *dynamometer* is shown in Plate V. Its object is to record the resistance of the model, being towed through the water of the basin. The dynamometer is attached to the carriage which runs to and fro on rails above the water. The model has vertical plates attached to it in the center line at each end which play with very little freedom between the pointers rigidly attached to the carriage, so that with practically no friction the model is constrained to move in the same direction as the carriage and without deviation, and at the same time is free to rise and fall, or change trim. The towing rod (10) takes the resistance of the model, and the fore and aft motion of the model, relative to the carriage, is very little.

The recording drum (44) is arranged to have sheets of paper about 16 inches by 22 inches secured to it somewhat as paper is secured to an ordinary indicator drum. The drum (44) is mounted upon a shaft which ordinarily can be turned by hand by means of the little hand wheel (49). Mounted loosely upon an extension of this shaft is a worm wheel (43) driven by a worm (42) which is connected by the parts numbered (41) to the main driving shaft (40), revolving with the wheels of the carriage. An electric clutch (50) seizes the worm wheel to the shaft or releases it, so that when desired the drum can be thrown into gear and driven at a speed proportional to the speed of the advance of the carriage.

Pencils (48), in connection with the magnets (47), record upon the drum "time" and "distance." The "time" pencil is connected with a break circuit chronometer (38), and records every second upon the drum. The "distance" pencil records contacts with pins spaced along the track 30.4 feet apart. This distance of 30.4 feet is 1/200 of a knot, a knot being taken as 6080 feet. From the record of time and distance the speed could be readily calculated, but in practice it is found that the working of the drum is so accurate that the speed can be read off directly by an arbitrary scale and the distance pencil is not ordinarily used. The length of record corresponding to 10 seconds of time is measured on a special scale which gives at once the speed in knots. This scale requires calibration and changing from time to time due to wear of wheels, etc. The distance record is used from time to time to check these direct readings in order to make sure that no wear of parts or lack of adjustment has vitiated accuracy.

Paper with metallic surface is used upon the drum, and the so-called pencils are really pieces of brass wire.

Considering the dynamometer proper, the spring (5) is connected at its rear end to the swinging cross-head (31), which is suspended by rod (19), about 4 feet long, and so arranged as to swing very freely. A pin runs through this cross-head over which the towing rod jaws fit loosely. Outboard of the towing rod on this pin are vertical and horizontal flat surfaces upon which knife edges (34) in the saddle (9) bear. The cross-head moves in the guide (35) rigidly bolted to the fixed bracket (2). Its travel is about ¾ of an inch between positive stops (32). At the extreme end of the rod, just below the cross-head, are electric contacts (33), adjustable and usually set so that the contact is made on either side just before the cross-head reaches the positive stop, which is also adjustable.

The forward end of the spring is attached to a screw (6), which is secured to the lower end of the traveling bracket (1). Attached to this traveling bracket is the arm (20), carrying the record pencil (21), which then marks upon the drum the exact position of the traveling bracket and thus determines the position of the forward end of the spring. The rear end of the saddle (9) is fitted with horizontal and vertical knife edges (34), engaging vertical and horizontal surfaces on a pin attached to the lower arm of a bell crank lever. This bell crank is balanced upon knife edges (8) and carries by means of the scale beam (7) a scale pan (13). It also has attached to it the auxiliary beam (14) which is connected by double pivots to the pointer (15) which records upon the drum the position of the rear end of the spring. The distance up from the knife edge center (8) to the line of action of the pointer (15) being 5 feet 6 inches, while the distance down to the line of action of the spring is 2 feet, it will be seen that the motion of the rear end of the spring is increased at the pointer in the ratio of 2.75 to 1.

The dash pot (16) is filled with glycerine and has a hollow floating piston with detachable connection rod (17), the rear end of which engages, as shown, a pin in the bracket upon (14). The rear end is so suspended by the chain (18) that no weight is taken on the pin, and the latter has a play in the jaws of the connecting rod (17) of 1/16″ or so.

The traveling bracket (1) is actuated by a screw (4) being

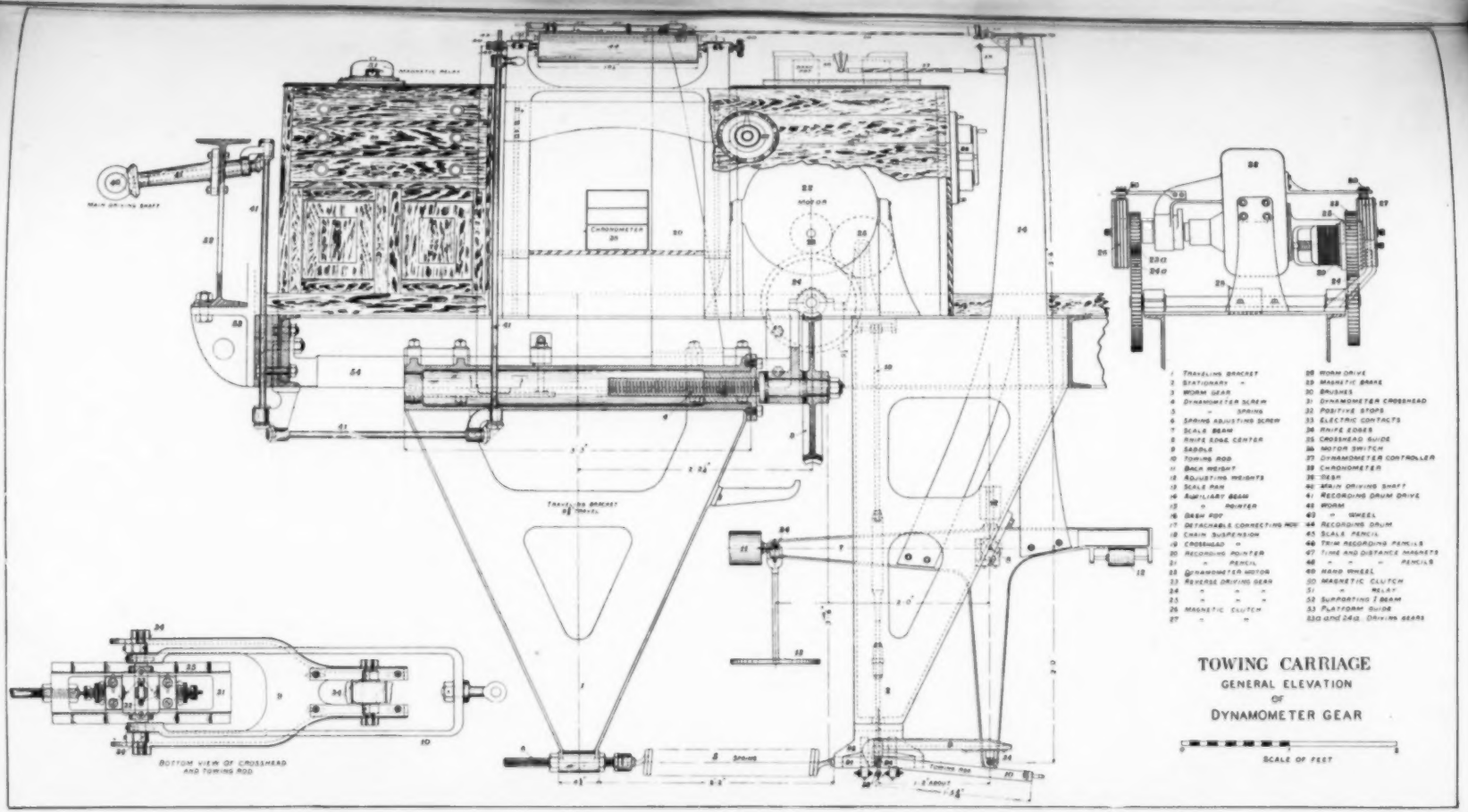

TOWING CARRIAGE
GENERAL ELEVATION
OF
DYNAMOMETER GEAR
SCALE OF FEET
BOTTOM VIEW OF CROSSHEAD AND TOWING ROD

PLATE V.

rigidly held by guides as shown. The screw (4) is driven by the worm wheel (3), which in turn is driven by the worm (28). This worm is upon a shaft which carries the gear wheels (24) and (24a), which mesh with the pinion (23a) and the idler (25); the idler (25) being driven in turn by the pinion (23). These pinions (23 and 23a) are loose upon the shaft of a motor (22), which is running all the time. At the ends of this shaft are magnetic clutches (26 and 27) which grip the pinions (23 and 23a). It will be seen that when clutch (26) is in gear so as to grip the pinion (23a), the traveling bracket (1) and recording pencil (21) must move in one direction, and when the clutch (27) has hold of pinion (23), the pencil (21) moves in the other direction. When both clutches are out, the pencil does not move, and the apparatus is so arranged that but one clutch can be in at one time.

There is a magnetic brake (29) upon the idler (25), so arranged that when neither clutch is in, a spring throws the brake in and thus promptly checks the motion of the pen when the clutch releases. When either clutch is in, the spring is held back by a magnet, and the whole gear moves freely. The clutches can then be thrown in by hand as desired, and in addition are connected through a magnetic relay (51) to the contacts (33) at the lower end of the dynamometer cross-heads, the connections being such that when the cross-head swings against the rear contact (33) the bracket with the recording pencil (21) is screwed forward, and when contact is made forward the bracket is screwed back. This is done automatically when the switch with the magnetic relay is in.

The various electric contacts for operating the device described are all controlled by the handle of the controller (37). When the pointer is brought opposite "tension" the traveling bracket is screwed forward so as to give the spring tension. When it is brought opposite "release" it is screwed back. When it is brought opposite "automatic" the contact arrangements just described (33) automatically traverse the traveling bracket (1). Then as the pointer reaches "drum" the drum is set in operation, and as it reaches "time" the time pencil begins to record, and as it reaches "distance" the distance pencil begins to record. In practice, in making a run, when it is desired to begin the record, the pointer is thrown at once to the right until it reaches "distance," when all the operations above described are in.

The following process of adjusting the apparatus and calibrating the spring is used:

Before putting in the spring, the cross-head is brought to its central position by means of the balance weights (12) upon the bell crank, and care is taken that the cross-head swings in this position whether the pin securing the scale pan (13) rigidly to the scale beam (7) is in or out. The position of the auxiliary pointer (15) is then noted. There are fitted, so as to mark upon the drum when desired, a number of fixed pencils, such as (45), which can be set to record at any position. One of these, called the auxiliary zero pencil, is now set so as to indicate always the position of the auxiliary pointer (15) when the cross-head is central and everything balanced.

Next the spring (5) is slipped into place and a corresponding back weight (11). The record pencil (21) is then brought to a convenient position for zero of the main scale, and a scale pencil set to mark always this zero. By adjusting the screw (6) forward or back, as may be required, the auxiliary pointer is brought back to its zero. When this is the case the back weight (11) gives the spring a certain initial tension by means of the saddle (9) and cross-head (31), while at the same time the cross-head is swinging freely in exactly its natural or zero position. Supposing the spring in use is a forty-pound spring, or a spring which, at its maximum extension of 9 or 10 inches will record 40 pounds. It will be noted that the extension of the spring is not from its natural position of equilibrium or from zero tension, but from its arbitrary zero position, the amount of tension at the arbitrary zero depending upon the amount of back weight used. It has been found that the springs are more reliable if given an initial tension by the use of such a back weight. The scale pan (13) is next allowed to swing freely, and a weight of ten pounds placed upon it. This extends the spring until the cross-head brings up against the positive stop. The bracket (1) is then screwed forward by throwing the motor in gear until the auxiliary pointer again comes to zero. A scale pencil (45) is now set to mark the position of the recording pencil (21). Twenty pounds is now placed upon the scale pan and equilibrium again restored by screwing the traveling bracket forward. Similarly thirty and forty pounds are used. The scale pencils, such as (45), now record upon the card lines which correspond to extensions of the spring, measuring 10, 20, 30,

and 40 pounds. The weights are removed, the recording pencil (21) returned to about its zero position, the scale pan (13) clamped in its zero position, and the work of adjustment and calibration is complete.

The model is then attached by the towing rod (10), which it will be seen (although it may be at an inclination) transmits to the spring only the horizontal pull upon it, the resistance of the model being all in a horizontal plane. It is customary to start a series of runs with the lower speeds and work up by degrees to the highest speeds, plotting roughly the results as they are obtained after each run. In this way, knowing the speed of a run about to be made, the approximate corresponding resistance can be guessed at very closely, and it is the practice to set the record pencil (21) approximately at this position before making the run, so that the automatic appliance may be called upon to traverse it as short a distance as possible.

It is evident that if, during the run, the auxiliary pointer swings from its zero position, the indication of the record pencil (21) must be corrected according as the auxiliary pointer is above or below its zero position. The correction is evidently $1/2.75$ of the deviation of the auxiliary pointer, supposing the extension of the spring to be such that its stress diagram is a straight line. It is found in practice that the stress strain diagrams for the springs used are practically straight lines. The operator can, however, after experience and practice, by means of a touch of "tension" or "release," bring the auxiliary pointer very close to zero during the majority of runs, so that the automatic devices do not come into play at all, although thrown into gear.

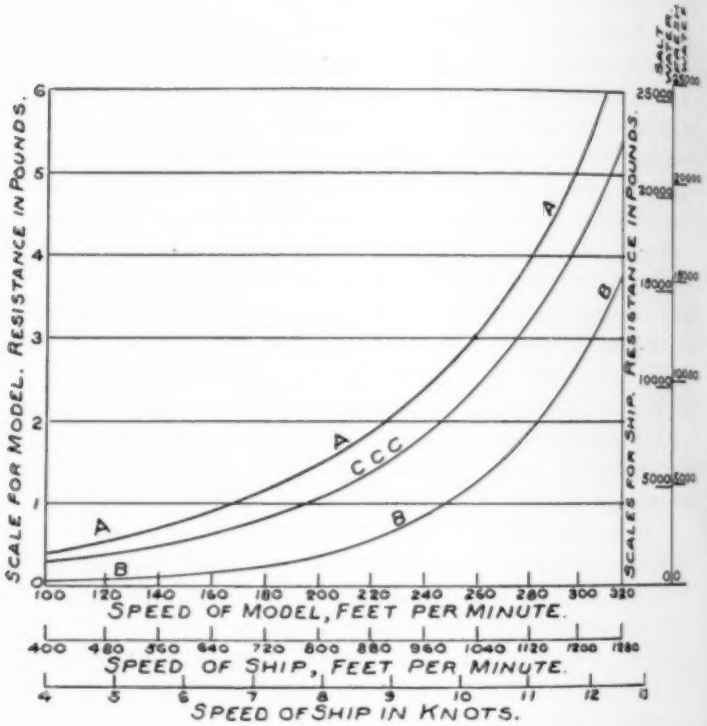
Plotting.—Supposing the difficulties to have been overcome, we can plot the results of towing experiments upon a model in the shape of a curve, such as AAA, in the figure below, showing the resistance in pounds of the model plotted upon speeds as abscissæ. This curve represents the total resistance, made up, as we know, of skin resistance, eddy resistance, and wave resistance.

We also know that the latter two alone (eddy resistance and wave resistance), constituting the residuary resistance, follow the Law of Comparison.

The first step, then, is to deduct from the total resistance the skin friction, which is calculated from the wetted surface and the results of experiments on planes of various character. Set-

ting down the skin friction from the curves *AAA* in the figure, we obtain the curve *BBB*, representing the residuary resistance of the model. Now we know from the Law of Comparison that this curve also represents the residuary resistance of the ship, provided the scales of speed and resistance are suitably changed.

In the case shown by figure, the model was 1/16 the size of the ship; hence, corresponding speeds of the ship and model are


SCALE FOR MODEL. RESISTANCE IN POUNDS.
SCALES FOR SHIP. RESISTANCE IN POUNDS.
A
B
C C C
SPEED OF MODEL, FEET PER MINUTE.
SPEED OF SHIP, FEET PER MINUTE.
SPEED OF SHIP IN KNOTS.

in the ratio $\sqrt{16}$: 1 or 4: 1, and residuary resistances at corresponding speeds are in the ratio 16^3: 1, or 4096: 1.

Drawing in the scales for the ship as shown, the curve *BBB* represents the residuary resistance of the ship in either fresh or salt water, according to the scale used.

Salt water resistance = 1.026(fresh water resistance).

It is now necessary to calculate the skin resistance of the ship, and set it up above *BBB*, to obtain the curve *CCC*, which represents the total resistance of the ship.

From the above it is evident that the relative resistances of different forms of models may be obtained and plotted in such form as to be readily comparable.

To obtain an estimate of the horsepower required to drive a given form of ship at certain speeds these resistances and speeds may be readily converted into horsepower by the formula:

$$\text{H. P.} = \text{ft. lbs. per minute} \div 33000.$$

The figures so obtained permit plotting a curve of effective horsepower or E. H. P. required.

The tabulation and careful consideration of results of many experiments and trial trips permits the determination of a factor giving the ratio between indicated horsepower and effective horsepower, and assuming, after due consideration of the conditions obtaining, a value for this factor, a curve of probable indicated horsepower or I. H. P. may be obtained.

I. H. P. is an expression too well known to require defining.

In the case of turbines, the measure of power obtainable from the completed installation is taken from the shaft and therefore becomes brake horsepower, or B. H. P., and the factor giving the ratio between B. H. P. and E. H. P. will differ considerably from that giving the ratio between I. H. P. and E. H. P.

The foregoing deals only with a small portion of the functions of the experimental tank, which is of value for a wide range of experiments in connection with ship resistance and ship propulsion.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE EROSION OF GUNS.

By JOHN F. MEIGS.

Guns are nowadays similar. That is, if a unit of length be one caliber and drawings be made of guns of varying calibers, the drawings of guns of all calibers will be the same. If we make a drawing of a 50-caliber 12-inch gun and of a 50-caliber 3-inch gun, using 12″ and 3″ as units of length, the two drawings will be superposable. The chambers, the lengths of travel of the shot in the bore, etc., will be the same. Also all guns are now similarly loaded.

The charges of powder and projectiles in guns vary as the cubes of the calibers, and breech and muzzle powder pressures are equal in all guns of the same system. The velocities at the muzzle, at the middle point of travel, or at any other homologous point, are also equal. That is to say, in existing guns of the same system (a fixed number of calibers long), the pressures, temperatures, and velocities at homologous points, such as the shot's starting point and its escaping point at the muzzle, are equal, when the guns are similarly loaded. Also the average velocities between homologous points are equal. Thus the time elapsed as the shot passes over the distance between homologous points, as the distance from the shot's starting point to the gun's muzzle, increases uniformly with the caliber.

Thus it takes the shot four times as long to escape from a 12-inch as from a 3-inch gun, and the gun walls are four times as long subjected to the strain of the pressure, and the surface of the bore is four times as long subjected to the scoring rush of gas of equally high temperature moving at equal speed. The temperature of the gas is equally high and its speed the same because the pressures at homologous points in guns of the same system are equal. The pressures at the start of the shot and

when it escapes at the muzzle are equal in all guns of the same system, when similarly loaded. Thus each time guns similarly loaded are fired the length of time any homologous point is subjected to gas of the same temperature flowing at equal speeds increases directly with the caliber. It is four times as long in a 12-inch gun as in a 3-inch gun.

At 38,000-lbs. pressure, which is about the chamber-pressure in 50-caliber guns when the muzzle velocity is 3000 f. s., the temperature of the gas is about 2000° F. The temperature of melted steel is about 2800° F, and that of a welding heat, which without great care will "burn" steel, or render it friable and granular, ready to be easily rubbed or carried away, is about 2000° F. And steel at 800° or 900° F, when it first shows color, is markedly softer and less strong than at ordinary temperatures. It is reasonable in view of these figures to conclude that the accuracy-life of similar guns decreases faster as they are fired than in simple ratio with the increase of caliber. The accuracy-life of a 0.33-inch gun with pressures of 38,000 pounds is about 3000 rounds, and thus an upper limit of the life of a 12-inch similar gun is $\frac{3000}{36} = 83$ rounds.

Large guns therefore cannot be fired as often as small ones, and no one hopes or desires to fire a very large gun as often as a hand rifle. If guns of all calibers are to be fired an equal number of times, gas pressures and temperatures must be lower in large than in small guns. It will be noted that nothing is said as to the flame-resisting quality of the surface of the bore, or the nature of the arrangements by which gas is prevented from escaping between the gun's surface and the projectile. Small guns can be at least as well arranged in these regards as large ones.

The accuracy-life of a 0.33-inch 50-caliber gun at 38,000-lbs. pressure being 3000 rounds, the accuracy-life of guns is not more than as follows:

	Rounds.		Rounds.
0.33″	3000	6″	166
1″	1000	8″	125
3″	333	10″	100
5″	200	12″	83

It may be added that guns may still be used after this number of rounds have been fired, since these figures indicate merely

the point at which their accuracy is probably impaired. The muzzle velocity they give is not much altered, but they would be less accurate and the projectiles more liable to tumble in flight. If it be claimed, as is probably the fact, that the 50-caliber 0.33-inch hand rifle will still be a pretty good weapon in battle until it has been fired 4500 or more rounds, it may also be claimed that the number of rounds which can be fired from the larger guns before they are very ineffective can be similarly extended. At the number of rounds stated, the accuracy of their fire is sensibly affected, nothing more.

A MANUAL OF THE LATEST APPROVED MATERIAL, INCLUDING ITS USE, OPERATION, INSPECTION, CARE, AND MANAGEMENT, AND METHODS OF INSTALLATION ON BOARD SHIP.

By COMMANDER BURNS T. WALLING, U. S. Navy, and JULIUS MARTIN, E. E., Master Electrician of the Equipment Department, Navy Yard, New York.

CHAPTER X.

THE INSPECTION OF GENERATING SETS AND MOTORS.

Generating Sets.

To avoid loss of time and labor and to accommodate the tests to the prescribed navy yard hours for employees, the inspection for compliance with the specifications is divided into three stages: Preliminary Inspection, Preliminary Test, and Final Test. Throughout the inspection all features peculiar to the design, all incidents of operation, and every departure from the specifications are noted minutely as they have an important bearing on the final consideration as to acceptance.

Immediately before the test the voltmeters, ammeters, tachometers, hand counters, and indicators are calibrated by the standards and the factor expressing their accuracy is noted on the test sheets. Thermometers should also be checked; it is found convenient to use the centigrade instruments.

Preliminary Inspection.—The weight is first taken. The generating set is then set up on an iron test plate, on a heavy foundation, to insure against vibration. The section of the test plate resembles an assembly of closely placed railway rails; under the flanges are slipped the heads of large square-headed bolts, the nuts being set up on iron dogs so placed on the generating set bed-plate as to hold the set securely.

The preliminary inspection can be held while the set is being piped up, its object being to examine into all the details of dimensions and mechanical construction required by the specifications, or in accordance with the dictates of good, up-to-date engineering and electrical practice and workmanship, which can be investigated

without deranging the assembly and adjustments as made by the contractor; all items necessarily omitted at this time are investigated by taking the set apart after the final test. Where doubts arise as to the material employed recourse is had to the drawings, and, if necessary, to the advisable chemical or physical test. *A case has occurred in which a cross-head was found to have been made of cast iron.* It is the intention of the specifications to produce a generating set which shall be first class in every particular of design, construction, or operation. Any omission from the specifications of any part of the machinery necessary to produce the result, or failure to describe the design and construction does not operate to release the contractor from supplying such part of the machinery, or from performing such work as part of his contract without additional expense to the Government.

As all items of mechanical construction are entered into at length in official specifications, attention is called only to the following, which require explanation:

1. *The general appearance of the set resulting from design must be of the highest character.* This item includes details and working parts together with the general make-up and finish of all. Nice finish and appearance supply the incentive for future care and attention.

2. *The standard sizes, with their corresponding maximum allowable speeds, weights, and overall dimensions are* (see table, page 163): The length and width are measured between the four vertical planes which would enclose the set; the height is measured from the lower edge of the bed-plate (or from the lower edge of the dynamo frame if the frame dips below the bed-plate) to the horizontal plane across the top of the cylinder covers, or across any self-contained connections projecting over the cylinders, such as bolt heads. It is common in investigating this item to find excesses in dimensions, especially in length, and in the prescribed weight; they afford fruitful sources for the consideration of waivers, and are antagonistic in their effect on design.

3. *The design must afford accessibility to all parts usually requiring inspection under operation, or adjustment when under repair.* The general idea is to prevent crowding and complication of parts.

4. *The driving shaft to be fitted with thrust collars or other*

suitable device which will prevent a movement of the shaft in the direction of its length, due to magnetic drag or the pitching or rolling of the ship. The dynamo armature will then remain central in its field as regards motion in the direction of the axis of the shaft.

5. *The driving is to be effected by a cross key set in the coupling faces.* This is a precaution against looseness and lost motion at the coupling; the cross key is to relieve the coupling bolts of the driving stress and prevent strain.

6. *The engine cranks are not to dip into the oil in the reservoir.* This has two distinct advantages: it permits a clear view of the cranks while running, and prevents churning the oil to a lather inside of the casing. The item includes counterweights, when placed opposite the crank.

7. *Relief valves, in addition to the drains, to be fitted to each end of each cylinder; their seats to relieve the cylinder of water.* It is important that the relief valve springs be non-corrosive.

8. *The length of the stroke of the engine is not to be less than the diameter of the bore of the high-pressure cylinder.* This keeps the per cent of clearance within good limits, and prevents the altering of this percentage by so small a mechanical clearance distance as will be dangerous in operaton.

9. *Stuffing boxes for piston rods and valve rods must be accessible from the outside of the engine casing.* If the stuffing boxes are put in on a driven fit, an arrangement for locking must be provided or the boxes will turn.

10. *A guard plate is to be provided to prevent throwing of oil against the lower cylinder heads and lower ends of the valve chests.* This item applies to those constructions in which the lower cylinder head or the lower end of the valve chest is exposed to the inside of the casing. The oil thrown against these lower ends not only produces a cooling effect but will carbonize and drop as grit on the moving parts and work into the journals.

11. *The method of securing the lagging must provide for its ready removal, repair, and replacing.* It is important that the surfaces concealed by lagging should be inspected for defects in casting or joints.

12. *Blank flanges are to be supplied for the alternative outlets.* One steam outlet at the end is the common practice; two outlets for exhaust are necessary.

13. *Piston rods must be securely fastened to the cross-head.* The common practice of fitting the rod to the piston end is a taper turn with shoulder, set up by nut and jam nut, the jam nut being secured from turning on the thread by a split pin. A screw and clamp connection at the cross-head end is very objectionable and is quite sure to work loose.

14. *The shunt and series windings of each field coil are to be separately mounted on the field core.* The intention is that they shall not be wound in combination, one over the other, on the same spool, but shall slip on and off separately.

15. *The bolts holding the armature core not to pass through the discs.* The governing principles of the construction of an armature core are: that it shall drive well without mechanical strains; to avoid Foucault currents which would heat the core and raise the temperature and resistance of the winding (which would in turn cause more heat); to afford such good ventilation as will carry off heat and keep the core and winding cool.

16. *The commutator bars to be securely clamped by bolts and clamping rings.* This should assure the prevention of the occasional case of unevenness in the bars, or sluing out of parallelism with the shaft, occurring from light force or pressure.

17. *The brush-holders are to be staggered.* In order that the wear may be evenly distributed over the entire range of the commutator surface.

18. *Make the following examinations:* Interior of cylinder and valve chests for fins, scales, sand, and foreign matter or tools that may have been left in the ports or in the interior.

Interior and bottom of casing for core sand, and foreign matter which will drop on the working parts or mix with the oil in the reservoir.

That all bolts and nuts are tight and secure.

That there are no scores or abrasions of the cylinder and valve chest surfaces to permit leakage of steam past the valve or piston.

That all generator connections are bright, tight, and secure; and the interior of the core, surface of windings and fields, and commutator are clear of dirt and grit.

Preliminary Test.—The object of this stage is to test items which require only a short run of the generating set; to assure the general readiness of the set for the final test; and to make any

necessary adjustments, such as for speed, compounding, or engine regulation.

1. *Cold Resistance of Armature, Series, and Shunt Fields.*—Just before starting the set, the cold resistances of the armature, series and shunt windings, and the temperature of the air, are measured as a check on those to be taken before the heat run of the final test. Accuracy of cold resistances is very essential; with the small differences in resistances obtained for the armature and series windings for the calculation of heat rise, the low resistances of the armature and series windings, and the haste necessary in measuring the hot resistances, accuracy in cold resistance is the main dependence.

2. *Insulation Resistance (Ohmic).*—The insulation resistance of windings is least when hot, and is measured cold in this stage for the purpose of developing any injury which may have occurred during shipment, or by the absorption of moisture; the moisture can be dried out either under load or by baking at a low temperature.

A 500-volt storage battery is connected to the switchboard leads, to which are connected two flexible leads having a 500-scale voltmeter in circuit. The insulation resistance is then taken by the Voltmeter Test. The insulation resistance should be a megohm for the following measurements:

Armature winding to shaft.

Series winding to shunt winding.

Shunt winding to magnet frame.

Each brush-holder to rocker.

Positive brush-holder to negative brush-holder (brushes up).

If low insulation resistance develops in either field each coil of each field is tested out separately.

3. *a. The Armature is to Run True.*—After a trial run to ensure that all parts are working properly the engine is brought to full speed. The armature and crank shafts are gauged by a machinist's surface gauge, secured at any convenient point, to develop that the shafts are true and central in their bearings. The commutator is then similarly gauged to determine that it is concentric with the shaft.

b. The Armature is to be Balanced Mechanically.—This is tested by placing graduated wedges between each pole piece and

the armature surface and taking measurements at the edges of the pole pieces while revolving the armature by hand.

c. The Armature is to be Balanced Electrically.—An armature which does not run true and is out of balance mechanically or magnetically will not run smoothly and without vibration, and will heat and spark from the inequality of the currents generated in the different sections of the armature. Separate excitation is preferable in testing magnetic balance as giving a more constant field.

The brushes are first examined for good contact on the commutator, and whatever trimming or dressing is required is done at this period of the inspection.

The brushes are first spaced equally all around the commutator, the toe of each brush being brought to line marks which are equally spaced on a strip of paper laid closely around the commutator.

The generator is run without load and the shunt field separately excited. The voltages between consecutive pairs of brushes are then measured separately for each pair, all brushes except the pair under measurement being at that time off the commutator. The admissible variation in voltage for any two pairs of brushes is one volt; if greater than one volt, the field frame must be adjusted to bring the armature magnetically central in the field, due care being exercised as to the mechanical clearance. Measurements by voltmeter are not applicable if the armature is cross-connected, and mechanical measurements of air gap under each pole, with the field both on and off, are employed instead; it can be accurately accomplished by graduated wedges. If faulty, the resistances of the various field coils should be separately measured to ascertain if the fault is due to differences in their construction.

It is useless to test electrically for magnetic balance if the armature is provided with equalizing rings.

4. *The Generator is Next Connected Up for a Short Operation under Various Stages of Load.*—The load is applied gradually, the effects on working parts, oiling system, etc., are noted, and particularly the stability of the voltage and the sparking. With a new machine the voltage will frequently not be maintained, due to a weak field, arising from opposition of the series and shunt fields or from one or more reversed coils; if not due to these causes the field is weak in original design and unsatisfactory.

A weak field will produce excessive sparking in as much as the armature current will cause greater distortion of field and consequent farther shifting of the neutral point; shifting the brushes may correct the sparking but the voltage will drop.

5. *Compounding.*—The compounding test required by the specifications is that for the maximum temperature of the windings after running at full load. The test of this stage, or cold compounding, is for the purpose of checking the action of the series shunt.

6. *Valve Setting and Steam Distribution.*—After the compounding test, the set is run for a short time at normal steam pressure and voltage and a good set of indicator cards obtained for full and no load from which to investigate the distribution of load between the cylinders and the correctness of the valve settings.

7. *Engine Regulation.*—This item is principally for the purpose of testing the governor action. Two readings, breaking from full to no load, and no load to full load, in one step, are all that are necessary.

Observations are made of the effect on, and action of, the various working parts; jump in voltage; ability to maintain rated voltage; sparking; tendency to throw oil; sluggishness, racing, and hunting; and general performance. If the governor requires adjustment it is effected by the methods explained for the different types of generating sets; after adjustment the regulation is again tested.

8. *Operation on Overload.*—The load is raised to one-third overload, for a short run, to test the strength of the working parts, to observe any sparking or flashing, and that the speed and voltage are maintained under the condition.

Final Test.—The third stage is to be exhaustive of specifications as to operation of both engine and generator, and as to all mechanical provisions omitted in the preliminary inspection. All reasonable adjustments having been effected in the preliminary test no others are permitted.

An interval of twenty-four hours should elapse between the preliminary tests and the final tests in order that the generator windings, which had been heated under load, may cool down to the temperature of the surrounding air, and in order that the heat run may not start with an initial heat rise in the windings.

To determine what, if any, initial rise exists, thermometers are placed (and protected from draughts) on the commutator, armature core, and within the field coils. Their temperatures are then compared with that of the surrounding air; the comparison is preferably made with the temperature shown by a thermometer which has been placed on the armature core of an adjacent idle machine, as its temperature represents more accurately the actual machine conditions.

1. *Measurement of Cold Resistances of Armature, Series Field, and Shunt Field Windings.*

The resistances are measured by the fall of potential, or drop method.

a. Armature Winding.—The fall of potential is taken between two appropriately selected commutator bars. The distance of these two bars apart, counted by bars around the periphery of the commutator, depends upon the number of poles; for a 4-pole generator the distance is one-fourth the total number of bars; for a 6-pole, it is either one-sixth or one-half; for an 8-pole, it is one-eighth or three-eighths. In the optional cases, that parallel combination of the total winding is taken which will give the higher resistance; for example, in a 6-pole machine one-half the total number of bars, in an 8-pole, three-eighths. It is not the working resistance of the armature which is desired but a sufficiently representative integral resistance, and it is sufficient to take the resistance between any two bars which are conveniently located under brushes of opposite sign. In case the generator has an *odd number of pairs of poles* these bars should be taken as nearly diametrically opposite as possible; if the total number of bars be even, the bars can be chosen exactly so. With an *even number of pairs of poles* the bars are chosen at a distance apart which is as nearly as possible some exact fraction of the total, care being taken that the selected bars come under brushes of opposite polarity; if it be more convenient the intervening distance can be exactly that between two consecutive sets of brushes.

It is necessary that the same bars be chosen for both the hot and cold resistance and to ensure it the selected bars are marked on the end by a small hand drill; the use of a center punch may start the bar and produce unevenness in the commutator.

To ensure that the current flows only in the two bars which

were marked by the drill, all brushes are lifted except those over the two marked bars. If the generator has a number of brushes per stud but one brush is used at each bar.

A strip of copper is laid on each punched bar and must be narrower than the bar to make good contact; the brush is then placed in contact with this strip. If the copper strip should cover more than one bar the current will flow through the armature in a very different manner than as above prescribed and the results be erroneous. The use of a small strip of copper under one brush precludes the use of a large current in measuring, but excellent results will be obtained with currents at and below 10 per cent of the rated amperage of the machine.

The armature resistances are taken cold at the start of the heat run, and hot at its completion, in order that the rise in temperature of a winding may be calculated. This method of determining the heat rise is that in long use and adopted by the American Institute of Electrical Engineers, June 20, 1902, for Electrical Generators, Motors, and Transformers, in the following citation: (Evidently the average rise only is contemplated, the highest rise being that in the portion of the windings approximately midway between the surface and the core; the lowest is that of the outer or free surface.)

Rise of Temperature.

"**General Principles.**—Under regular service conditions, the temperature of electrical machinery should never be allowed to remain at a point at which permanent deterioration of its insulating material takes place,

"The rise of temperature should be referred to the standard conditions of a room temperature at 25° C., a barometic pressure of 760 mm., and normal conditions of ventilation; that is, the apparatus under test should neither be exposed to draught nor enclosed, except when expressly specified.

"If the room temperature during the test differs from 25° C., the observed rise of temperature should be corrected by ½ per cent for each degree C. Thus with a room temperature of 35° C., the observed rise of temperature has to be decreased by 5 per cent, and with a room temperature of 15° C., the observed rise of temperature has to be increased by 5 per cent. The thermometer indicating the room temperature should be screened from thermal radiation emitted by heated bodies, or from draughts of air. When it is impracticable to secure normal conditions of ventilation on account of an adjacent engine, or other sources of heat, the thermometer for measuring the air temperature should be placed so as fairly to indicate the temperature which the machine would have if it

were idle, in order that the rise of temperature determined shall be that caused by the operation of the machine.

"In electrical conductors, the rise of temperature should be determined by their increase of resistance where practicable. For this purpose the resistance may be measured either by galvanometer test, or by drop-of-potential method. A temperature coefficient of 0.42 per cent per degrees C., from and at 0° C., may be assumed for copper. By the formula

$$R_t = R_0\,(1+0.0042t) \text{ and } R_{t+e} = R_0\,[1+0.0042\,(t+e)]$$

Where R_t is the initial resistance at room temperature $t°C$. R_{t+e} is the final resistance at temperature elevation of $e°C$. R_0 is the inferred resistance at $0°C$.

These combine into the formula:

$$e = (238.1+t)\left(\frac{R_{t+e}}{R_t}-1\right) \text{degrees } C.$$

"Temperature elevations measured in this way are usually in excess of temperature elevations measured by thermometers.

"When thermometers are applied to the free surface of a machine it is desirable that the bulb of the thermometer should be covered by a pad of definite area. An unduly large pad over the thermometer tends to interfere with the natural liberation of heat from the surface to which the thermometer is applied."

The brush leads are first connected to the main leads to the switchboard, the latter being connected with a storage battery as the current will be more steadily supplied and obviate errors of self-induction. The circuit breakers of the switchboard are closed and the portable rheostat is connected up to supply that resistance in circuit which will adjust the current value; the armature resistance is so small—a small fraction of an ohm—that its resistance, in series with that of the portable rheostat, will have a negligible effect on the resulting current. A portable ammeter whose scale covers at least 10 per cent of the rated amperage is connected in the current leads. A portable voltmeter, 0 to 15 scale, is placed on the table and connected up to a standard set of leads, which are fitted with pointed terminals at one end to fit the punch marks, and with terminals at the other end for connecting to the voltmeter. When ready for the measurement a switch is closed on the portable rheostat which will afford approximately 2 to 5 per cent of the rated amperage of the generator. The pointed ends of the standard leads of the voltmeter are then pressed into the punch marks of the two commutator bars and quick, simultaneous readings of the ammeter and voltmeter taken. Exactly similar readings are then taken for two current adjust-

ments of the rheostat which are between that already used and 10 per cent of the rated amperage.

From the three voltages, or drops, and their corresponding currents three resistances are calculated by Ohm's law *and should not differ from each other by more than 1 per cent.*

Notes of Test.—The maximum current should not exceed 10 per cent of the rated amperage of the generator. Excellent results are obtained with small currents provided they are sufficient to give a reliable reading of the voltmeter; large currents will heat the winding and cause erroneous differences in results.

The pointed ends of the standard leads must be applied directly to the punched commutator bars themselves and not to a connection such as a brush-holder, brush, etc.; the injunction applies to an intervening brush, the resistance of carbon being negatively affected by a rise of temperature and thus causing error in the measured resistance.

The closing of the rheostat switch, the connection of the voltmeter to the bars, and simultaneous readings, must be effected with all practical despatch that the winding may be as little affected by the heating action of the current as possible. Break the voltmeter connections by the instrument key before opening or closing the load switch, to avoid injury to the delicate voltmeter by self-induced voltage. The shunt field must be opened at its switch before measuring or its resistance will be in parallel with that of the armature.

b. Series Winding.—The cold resistance of the series windings is measured in the same way as that of the armature; the measured resistance being that of all the series coils, on all poles, in series. The same approximate currents are used as in the test of the armature and are led by the brush leads. The resistance will be much less than that of the armature and a voltmeter of scale 0 to 0.15 is employed. The series shunt must first be disconnected.

The pointed ends of the standard voltmeter leads are held closely to the drill mark, which is to be as close to the end of the series winding proper as possible to avoid other contact resistances.

The precautions are the same in general as those observed in the armature measurement except that the series winding remains in series with that of the armature; the resistance of the latter

does not affect the readings, as the resulting drop is that of the series field only. To ensure good contact at the commutator several brushes should be let down. The three resistances should not differ by more than 1 per cent.

c. Shunt Winding.—The resistance of the shunt winding is, similarly to that of the series, taken for all the coils in series. The drop is comparatively high and will differ from the rated terminal voltage of the generator by from only 10 to 50 volts, according to size and design. The current for ordinary operation is small, and currents are therefore used whose maximum is the operating shunt current and whose minimum is about one-half this value. The load is adjusted by the shunt-field rheostat without the use of other load resistance. All brushes must be raised from the commutator, to avoid paralleling the armature and series windings with the shunt. A 0 to 150-scale voltmeter and a 0 to 15-scale ammeter are employed; they are connected up through flexible leads at the bottom of the switchboard. Adjustments of current are made by operating the shunt rheostat, *which must start with all resistance in when the field switch is closed.*

Precautions.—It is very important that shunt-field resistance readings be taken quickly; the field will heat rapidly under the amount of current used and such heat will have an appreciable effect on the result. The voltmeter must be out of circuit before the field switch is opened and until after it is closed; there is great danger of burning out the voltmeter, due to self-induction, or of bending the needle.

2. *Heat Run at Rated Full Load.*

The heat run is next started and consists of a 4-hour continuous run under full load, at normal steam pressure, rated speed and rated voltage. Its objects are to test the endurance of operation of both engine and generator, and to determine the heat rise of the windings.

When ready to start the set, place a thermometer with its bulb in a line with the center of the shaft and 3 feet from the commutator end of the generator, which will give the air temperature to be recorded and allowed for in each half-hourly computation of resistance. Place a second thermometer on the armature of an idle machine near by. Place a third thermometer on the shunt-field rheostat, protecting its bulb from air draughts.

The generator is connected up, as shown in the elementary diagram (Fig. 210); the steam pressure is regulated to the normal, the engine started up, the armature brought to rated speed and the vacuum to 25 inches. The shunt-field switch is closed and the rated voltage regulated, meanwhile taking several check readings

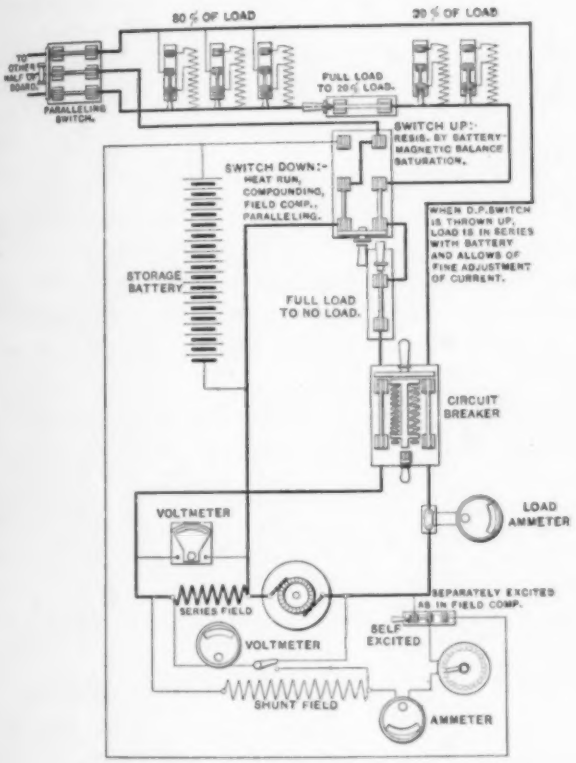

80 % OF LOAD
20 % OF LOAD
TO OTHER SIDE OF SWITCH BOARD
PARALLELING SWITCH.
FULL LOAD TO 20% LOAD.
SWITCH UP:- RESIS. BY BATTERY MAGNETIC BALANCE SATURATION.
SWITCH DOWN:- HEAT RUN, COMPOUNDING, FIELD COMP., PARALLELING.
WHEN D.P.SWITCH IS THROWN UP, LOAD IS IN SERIES WITH BATTERY AND ALLOWS OF FINE ADJUSTMENT OF CURRENT.
STORAGE BATTERY.
FULL LOAD TO NO LOAD.
CIRCUIT BREAKER
VOLTMETER
LOAD AMMETER
SERIES FIELD
SEPARATELY EXCITED AS IN FIELD COMP.
SELF EXCITED
VOLTMETER
SHUNT FIELD
AMMETER

FIG. 210.—Connections of generator for test.

of the drop on the shunt field. About 5 minutes later full load is thrown on in successive short steps, several check readings of the drop on the series field being taken while so doing, the series shunt being for the time disconnected. The field and load rheostats are then adjusted for rated voltage and amperage output, and so maintained throughout the run.

[NOTE 28.—The load used in Navy Yard and shop tests differs for different places and circumstances: for small machines banks of electric

lamps (with as many large lamps as practicable) are used and connected up to be conveniently divided by series and parallel connections into fractional currents; at the New York Navy Yard, the load consists entirely of rheostats of German silver ribbon, giving a capacity of 2000 amperes in series and convenient fractions thereunder; at contractors' works the load is provided mainly by water boxes, though lamp banks are used for lighter loads. The water boxes are plain boxes containing water and 1½ to 2 pounds of salt per cubic foot of water; a fixed plate forms one terminal, the other terminal being a movable plate, which, being adjusted in distance, gives the necessary resistance to adjust the current (load); as the water is evaporated by the boiling of the water in the box more water is added from a convenient tap.]

Readings of terminal volts and amperes, resistance of shunt and series fields, speed, steam pressure, vacuum, temperatures, pressure of lubricating system, etc., are then taken every half-hour. Each half-hour, as the readings are taken, the temperature rise of each field winding is calculated and plotted; these curves afford a convenient insight into the heat action; the trend of the curve at the end will indicate whether the rise has reached constancy.

The armature must maintain rated speed or the shunt field will be unduly heated from the extra current required to maintain the rated voltage.

The amperage of the shunt field is taken by a 0 to 15-scale portable ammeter connected to the flexible leads. When measuring the voltage of the series field, the series shunt is for a moment disconnected and the drop taken by standard leads connected to a portable voltmeter.

The following are the items of observation during the run:

I. The Set Must be Capable of Running:

a. Without Undue Noise.—Noise is an annoying fault on board ship. Whistling and grunting in the cylinders should disappear as the pistons wear smooth; this variety of noise occurs mostly under light loads from insufficient moisture in the steam to afford lubrication in the cylinders. The oil pump will be noisy if not designed with sufficient relief to obviate pulsation of pressure. Noise due to grinding of valves on their seats or to the pistons over-riding the counterbore are to be particularly investigated.

b. Without Undue Heating.—All bearings should run cool.

that is, sufficiently so to permit testing with the hand for a few seconds.

II. The Set Must be Balanced and Run True.

This refers to any tendency to get out of balance or to change from true by wear or alteration of alignment. It is tested by gauging.

III. The Set Must be Capable of Running for Long Periods Under Full Load and Without Continued Attention.

This item is not assured in acceptance tests except in the most general way; the specification refers more particularly to the contract guarantee for six months' operation after installation.

IV. The Driving Shaft Must be Fitted with Thrust Collars or Other Suitable Device which will Prevent a Movement of the Shaft in the Direction of its Length, as Might be Caused by the Rolling or Pitching of the Ship.

The shaft collars should prevent an end play of the shaft of more than ⅛ inch; a play of 1/16 to ⅛ inch is advisable from mechanical considerations.

V. Engines are to be so designed that the Work Done by Each Cylinder, as Shown by the Indicator Cards, will be as Nearly Equal as Practicable Under all Conditions of Load.

A set of indicator cards are taken every hour to verify this condition as well as to examine into the correctness of the valve settings and of the steam distribution.

VI. Engines are to Operate Satisfactorily Without the Use of Lubricants in the Steam Spaces.

The external evidence of insufficient lubrication in these spaces is a whistling or grunting noise. It is infrequent in vertical engines after the piston and valve edges become polished.

VII. The Engine Shall be Capable of Satisfactory Operation with a Low Grade of Lubricating Oil.

The oil used in the test operations consists of two parts of an oil which has been once used and afterwards filtered and one part of clean (new) oil. Arctic engine oil is used for new oil.

VIII. The Lubrication for all Working Surfaces, Other Than Those of Steam Spaces, is to be of the Most Complete Character. No Part Shall Depend on Squirt Can Lubrication.

Forced lubrication is to be used wherever practicable; the intent of forced lubrication is to reduce friction, noise, and attention. The pressure for forced lubrication is to be approximately 15 pounds per square inch, and to be between 10 and 20 pounds under all service conditions.

Grease cups are preferable for the governor-rod journals, journals of the governor assembly, and rockshaft sleeves. The outer pillow-block bearing at the commutator end should be of the ring-oiler type, showing the height of oil by a gauge; it is from this bearing that oil is most likely to flow to the commutator.

The stuffing-box surfaces are sufficiently oiled by that oil which is picked up in the casing by the valve and piston rods.

It is essential that the results of the devices for lubrication be noted in their separate action for each particular part that no fault may be overlooked which can occasion difficulties in service.

IX. The Oil Pump is to Handle Clean Oil Only, not Drawing from the Top or Bottom of the Reservoir.

That is, the receiver of the oil pump is not to be so located as to draw dirty oil from the top or bottom of the oil contained in the well.

X. To Permit Inspection While Running the Engine Crank is not to Dip into the Oil in the Reservoir.

XI. The Generator is to be Capable of Supplying the Rated Voltage at the Terminals when Run at Constant Speed.

XII. The Commutator Bars are to Line with the Shaft and Run True.

True running is tested from time to time by gauge, or by sighting the perimeter with some fixed adjacent object.

XIII. The Armature Shaft is to be Provided with Suitable Means to Prevent Oil from Bearings from Working Along to Armature.

The access of oil to the armature windings or commutator is a

fatal fault and it is absolutely necessary that no oil should reach the armature whether thrown on or by flow.

XIV. The Magnetic Leakage at Full Load Shall be Imperceptible at a Horizontal Distance of 15 Feet, Measurements to be Taken with a Horizontal Force Instrument.

This test is made by placing a detector or horizontal force instrument at radial distances of 15 feet whilst the field is excited to full strength, and noting any variation in deflection of the needle due to stray field. Multipolar constructions will rarely occasion any stray field even at a much less distance than 15 feet.

XV. The Design is to Eliminate all Chance of Oil or Water Leaking or Being Forced Through Enveloping Enclosures and Hinged Doors.

Defects of this nature occasion the throwing of oil or water on the armature and commutator and are very objectionable.

XVI. Any Disposition of the Working Parts to Weakness or to Work Loose or Develop Lost Motion is to be Carefully Noted with Probable Cause.

A particular item of attention is a tendency to change speed due to stretching of the governor spring.

XVII. There Shall be no Sparking when Load is Gradually Increased Between No Load and Full Load. (See note 20 and also remarks on sparking.)

As a rule sparking faults will develop in the preliminary tests.

XVIII. Water Consumption.

The normal steam pressure under which the engine, running condensing with 25-inch vacuum, for different sized sets, is to operate, and the maximum allowable water consumption per k. w. hour output of the set are:

K. W.	Normal steam pressure.	Water consumption per K. W. hour full load.
2.5	100	105
5	100	90
8	100	65
16	100	44
24	100	40
32	100	37
50	100	35.5
50	150	33.5
100	150	31

Corrections are made by calorimeter for entrained moisture. Superheating must not be used in the test.

The test is made during the last hour of the heat run in order to accommodate the working of the boilers.

Dry steam only is wanted and precautions must be taken to reduce the percentage of moisture carried over from the boiler; the branch steam pipe is to be lagged close up to the engine and the fireman notified to keep the water in the boilers at a constant level during the test, the level to be as low as is compatible with safety to the boilers.

A Carpenter Separating Calorimeter is tapped into the branch steam pipe as near the engine as practicable. The calorimeter consists of a small steam separator through which a sample of the steam supplied to the engine is passed and by which the moisture contained in the steam is removed; the dry steam flows on and is condensed into a can of cool water. A glass water gauge attached to the separator has a scale which reads the amount of water in the separator directly in tenths and hundredths of a pound; a similar gauge on the cooling can reads the weight of dry steam condensed. The quality of the steam is obtained by adding to the weight of the dry steam condensed during some convenient period of time, generally 10 minutes, the weight of moisture entrained in the separator during the same period. This gives the total weight of the sample of steam passed through the instrument; the weight of dry steam divided by this total and multiplied by 100 will give the percentage of dry steam for any given quantity of boiler steam supplied. This quality of the steam is checked for each water-consumption test. The calorimeter should be heated that the condensation may not give an undue amount of water, and the can in which the dry steam is condensed should be cooled off whenever it becomes warm.

It is sufficient for the purpose of the water-consumption test to weigh that amount of water which is condensed from the steam delivered to the engine in half an hour, taking two or three readings of quality percentage, for 10-minute intervals, by calorimeter. Two barrels into which the condenser discharges rest on platform scales and alternately receive the water which is weighed in the barrels, the tare being taken as often as a barrel is emptied. To insure accuracy the scales must be balanced before starting; the valves in the exhaust piping must also be inspected that only

the condensed steam from the engine under test may be charged and not water from other portions of the piping.

The condenser should be allowed to run several minutes before a reading is taken to ensure filling of stand pipes, etc. The weight of water delivered is taken every 10 minutes; the weights should check. The voltage and amperage is read at the same time and reduced to k. w.

From this data the steam efficiency of the set is calculated in pounds of water per k. w. hour. Total pounds of dry steam per hour and total pounds of dry steam per k. w. hour are then plotted and the curves drawn. A set of indicator cards are taken at the time of the test that the efficiency and water consumption may be calculated for the same period of the run.

XIX. Heat Rise.

The temperature rise of the set after running continuously at full rated load for 4 hours must not exceed the following:

	Method of measurement.	Maximum allowable rise in °C.
Armature	Electrical	33⅓
Commutator	Thermometer	40
Field coils	Electrical	33⅓
Shunt rheostat	Electrical	75
Series shunt	Thermometer	40

The rise of temperature to be referred to a standard room temperature of 25° C. and normal conditions of ventilation. Room temperature to be measured by a thermometer placed 3 feet from the commutator end of the generator with its bulb in line with the center of the shaft.

During the last half-hour of a heat run all apparatus is made ready and the thermometers warmed up in hot water, or better, on the cylinder of the engine; care should be taken not to warm the thermometers to a higher temperature than approximately that to be expected of the commutator or the armature core; it is best to have the readings rise to a maximum and then fall off, thus definitely determining the temperature of the required part. Five minutes before stopping several resistance readings of the shunt field are taken.

After the load has been on for 4 hours the engine is shut down.

The hot resistance of the shunt field is taken to be as that of the last readings of the heat run. The hot resistances of the armature and series field is measured by the fall of potential method, as in taking the cold resistance; all readings must be taken expeditiously as the windings will cool rapidly. The previously warmed thermometers are placed on the communicator, inside the armature core and on the pole tip. Two extra men are required for the thermometer readings in order that a running record may be kept of the thermometer readings while rising and until they begin to fall.

From the highest temperatures the heat rise of the windings is calculated by the formula on page 1014 and other prescribed rises by deducting the average temperature of the air during the run; the readings of the thermometer placed on the idle machine are those to be averaged in preference to the more exposed thermometer placed in line with the shaft as per specifications. All rises are then corrected by ½ per cent for any difference between the temperature of the air and 25° C.

XX. Heat Run at One-Third Overload.

The generator is to be capable of satisfactory operation for a period of 2 hours when carrying one and one-third times its full load, and no part to heat to such a degree as to injure the insulation.

The foregoing conditions are tested as soon as possible after the completion of the heat run by a 2-hour run at one and one-third times the rated load.

The time consumed in taking temperatures, shutting down, starting up, etc., will usually occasion appreciable reduction in the temperature of the windings, and it is therefore customary before starting the overload heat run to run the set on full load until the rise in the series and shunt fields is again at the value found for the completion of the full-load heat run; overload must not be employed for this as the series will heat faster than the shunt and a different condition result from that obtained for the heat run.

No heat rise is specified, the test of heat rise being merely the effect on the insulation as determined in the insulation test; this fixes the heat rise to a certain extent as cotton insulation will be

injured by a temperature above 150 degrees Centigrade; the rise is, however, calculated from the original cold resistances.

The same precautions and readings are observed during this run as in the full-load heat run. Careful examination is made as to the different items of general operation of the set.

Particular items of specifications are:

1. The sets must be balanced and run true at all loads up to one-third overload.

2. The engines are to be of sufficient horsepower to drive the generator for an extended time (two hours) when the generator is carrying one-third overload.

3. Engines are to be so designed that the work done by each cylinder, as shown by indicator cards, will be as nearly equal as practicable at all conditions of load.

4. The generator is to supply the rated voltage.

5. The point of contact of the brush on the commutator shall not shift by the wearing away of the brush.

6. There shall be no detrimental sparkling when load is varied up to one and one-third times the rated load; the yellow spark is detrimental even in small amount.

The ability of the engine to keep the rated speed during the run is to be carefully noted.

Indicator cards are taken especially at the time of taking the water consumption in the last hour. Resistances of shunt and series field are recorded every half-hour and the heat rise plotted; the armature resistance and temperatures are taken at the end. The run is recorded as in the full-load heat run.

XXI. Insulation Resistance.

The specifications provide that the dielectric strength or resistance to rupture shall be determined by a continued application of an alternating E. M. F. for 1 minute; the testing voltage for sets under 16 k. w. to be 1000 volts and for sets of 16 k. w. and above to be 1500 volts, and the source of the alternating E. M. F. to be a transformer of at least 5 k. w. capacity for sets of 50 k. w. and under, and of at least 10 k. w. capacity for sets of greater output than 50 k. w.; the test for dielectric strength to be made with the completely assembled apparatus and not with its individual parts, and the voltage to be applied between the electric

circuits and surrounding conducting material; the tests to be made with a sine wave of E. M. F., or where this is not available, at a voltage giving the same striking distance between needle points in air, as a sine wave of the specified E. M. F.; as needles, new sewing needles, are to be used; during the test, the apparatus being tested is shunted by a spark gap of needle points set for a voltage exceeding the required voltage of 10 per cent.

The insulation resistances are taken as soon as possible after the completion of the overload heat run when the conductors are hottest and of least insulation resistance.

In the test an alternating current transformer having a capacity of 20 kilowatts is used. The primary coils of the transformer are connected in series, secondaries in multiple, and the exact voltage is obtained by regulating the primary current, a rheostat being used for the purpose. Should a spark leap across the gap the needles are replaced before another test is made; the needle points will have burned away and increased the length of gap, thus increasing the striking voltage.

In applying this test the voltage to be used is determined as follows: Needles are first placed at a distance apart in the spark gap of 0.047 inch for 1000 volts and 0.071 inch for 1500 volts. The primary voltage is gradually increased until the secondary E. M. F. just produces an arc between the needle points. The primary voltage is now noted and is the primary voltage to be maintained during the test on the generator; it will be that which produces a secondary voltage of the same effective value as the sine wave value specified. The primary circuit is then opened, the needles are replaced by new ones, and the distance between them set for a voltage exceeding the required voltage by 10 per cent, at 0.052 inch for 1100 volts and 0.078 inch for 1650 volts.

The test is now made for the same items of the machine as in the preliminary test, the primary voltage being maintained at the value previously found; a static voltmeter across the secondary terminals gives a further check on the conditions.

There is no record made other than that the results were or were not satisfactory, if not satisfactory, the particular winding; evidently the insulation will either stand the test or it will break down.

XXII. Compounding.

The compounding is to be such that with the engine working within specified limits, field rheostat and brushes in a fixed position, and starting with normal voltage at no load or at full load, if the current be varied step by step from no load to full load or from full load to no load, and back again, the variation from normal voltage shall at no point be in excess of 2 per cent. The test is to be made when the windings are hot. The method of test is to take the generator characteristic. The combined action of the series and shunt fields to maintain a constant voltage and render the generator self-regulating is actually effected in the end by the series shunt and the whole effect is therefore referred to the efficiency of action of this shunt.

The normal speed and steam pressure is first assured and the voltage regulated to rated voltage for no load.

[NOTE 29.—This method of starting at no load may be regarded as severe though not unreasonable, and machines so tested will fall without the permissible limits. It is generally necessary to cut the field resistance all out, and then bring the voltage back to normal with a falling field: even then it will be often found necessary to take one or more full cycles of the compounding before the machine will assume a sufficiently stable condition for the actual test; for the start at full load this is not necessary and the adjustment may be made with either a rising or falling field.]

Commencing at no load, the voltage is read for increasing changes of load, usually for five equal steps of one-fifth of full load each (the steps should not be less than four), up to full load, and then down again to no load in an equal number of steps.

Full load is now put on and the voltage regulated to the rated voltage. The cycle is then repeated, but by decreasing to no load and then back up to full load. The results of the two cycles will probably differ at some points and both curves should be plotted.

At each reading the voltage and amperage of the series and shunt fields, and the speed and steam pressure are recorded.

The voltage having been adjusted at the beginning of a cycle the shunt rheostat must not be altered during the readings.

The brush rocker arm is to be set before the taking of a set of readings at the position used in the heat run. In other words, there must not be one position of the brushes for the heat rise test and another for the compounding; this meretricious artifice of using different brush positions is common enough in factory

tests and is a direct indication of insufficiency of copper in the armature winding and incorrect winding.

The changes of load must be continuous in the same direction or the results will be erroneous; *e. g.*, if changing load from 60 to 120 amperes, increase steadily to 120 amperes, but if in so doing more than 120 amperes is reached, do not shift back to 120 amperes but read the voltage for the load actually obtained; or if changing from 120 amperes to 60 amperes and the adjustment falls below 60, do not attempt to regain 60.

It is permissible that the voltmeter should become steady after each load change; if the changes up and down be made rapidly the voltage, when the load is stepped down to no load, will be greater than the original, due to hysteresis; it is sometimes separately done to test the hysteretic action of a new type of generator.

Although only the compounding between no load and full load and the reverse is specified, it is customary, inasmuch as the machines will be expected to operate in parallel in action, to continue the steps from no load up to one-third overload, the overload being one extra step. If the compounding, as per specifications, is in question the compounding up to one-third overload is tested separately.

XXIII. Engine Regulation.

a. The speed variation must not exceed 2½ per cent when load is varied between full load to 20 per cent of full load, gradually or in one step, the engine running with normal steam pressure and vacuum. A variation of not more than 3½ per cent is allowed when full load is suddenly thrown on or off the generator, with constant steam pressure either normal, 20 per cent above, or 20 per cent below normal, and exhaust either to condenser or to atmosphere. No adjustment of the governor or throttle valve during the test is to be necessary to ensure proper performance under any of the above conditions.

b. The jump in voltage must not exceed 15 per cent when full load is suddenly thrown on and off.

This test will demonstrate the ability of the engine to steadily maintain its rated speed under varying or sudden changes of load; whether the governor is in proper adjustment to control the engine speed under various loads; the strength of the various working parts to sustain abrupt changes of load in emergency, and the effect of sudden changes on the voltage.

The generator is connected up to the switchboard and load. A tachometer is applied to the end of the shaft and placed on a rest, to keep it steadily in place and as a convenience for the observer. A voltmeter is connected in at the generator terminals to test the jump in voltage. The steam pressure is carefully regulated to the normal and maintained at that reading. The rated voltage is adjusted by rheostat for no load.

The load is gradually applied by means of the load switches, and adjusted until full-rated load is indicated by the ammeter, the speed and voltage being noted for each change as the load is applied; the load is then gradually reduced to no load and the same observations taken. Full load is then switched in for the other regulation tests. The speed is not to be less than that for which the generator is rated.

The engine operating on the condenser, the circuit breaker is tripped, and the highest, lowest, and steady speed recorded, and also the highest, lowest, and the steady voltage; the circuit breaker is then closed and the same readings again taken. The cycle is then repeated. The air valve on the condenser is next opened and two similar sets of readings obtained for the operation on atmospheric exhaust. These tests have ascertained the action from full to no load on both vacuum and atmospheric exhausts for the normal steam pressure.

Twenty per cent of load is next adjusted through the circuit breaker and a similar set of 2-cycle readings is taken for full load to 20 per cent of full load for vacuum exhaust.

The steam pressure is then changed by the reducing valve to 20 per cent excess above normal pressure, and similar readings of speed and voltage are taken for full to no load and reverse, on both vacuum and atmospheric exhaust.

The steam pressure is then changed to 20 per cent less than normal pressure and a like full set of readings are taken, for full to no load and reverse on both exhausts.

Notes on Test.—If the governor shows erratic action it may be due to the sticking of some part, or to friction in bearings.

Normal steam pressure and voltage is to be assured at each set of readings.

Care is to be taken, especially in breaking the load from full to no load or to 20 per cent of full load, that the drain valves are tightly closed and the vacuum at 25 inches; the engine will evi-

dently regulate better under the conditions for atmospheric exhaust or reduced vacuum; *it is well to seal the drain valves to obviate tampering.*

In making changes from full load to 20 per cent of full load the tachometer and voltmeter are watched to detect "hunting," a bad and inadmissible fault. Hunting is that condition in which the engine does not readily assume the new steady speed but oscillates back and forth before settling to the steady speed; a good governor should bring the engine promptly to steady speed and without wavering.

In making the changes of load the working parts of the engine are to be closely watched to see that they bear the strain well.

The high, low, and steady voltage of each change indicates that the generator maintains the rated voltage and that the series shunt is adjusted to sustain that voltage within those limits which will not endanger lamps, etc., of the installation.

Racing at no load is a bad fault and is to be especially noted.

No adjustment of the throttle or governor is to be made to secure performance under any of the conditions. The engine is to be run with the throttle wide open; the governor should be capable of regulating the steam supply.

While it is not usual in the test to open the field circuit to accentuate the effect of the removal of the load, it is sometimes done for the purpose of ascertaining whether the clearance is so great as to permit the engine to race should the field circuit be broken.

XXIV. Overload.

a. The engine must be able to bear without injury the sudden throwing on or off of one and one-third times the rated full load of the generator, by making and breaking the generator's external circuit. Two readings are taken, the various working parts of the engine being closely watched, especially the governor action and voltage effect.

b. With brushes in a fixed position there is to be no flashing when one and one-third rated load is removed or applied in one stage. The overload is adjusted for normal steam pressure, speed and voltage. The circuit breaker is tripped and the effect on the working parts and any flashing noted. Flashing occurs mostly

in those improperly designed machines in which the neutral point shifts through a wide range. It is more convenient and to the saving of time to make these tests by breaking the load suddenly at the end of the overload heat run.

XXV. Magnetization or Saturation Curve.

This test is made on one generator of a delivery of two or more to complete record data; it will develop the sufficiency of the field-core areas and is useful in tracing defects in compounding.

The field of the machine is separately excited by the storage batteries; the armature is driven at constant speed, and a voltmeter is connected to the brushes for the voltage generated; before starting the residual magnetism should be "kicked out" of the fields. At the start the increase in voltage is great for small increments of current; the latter is raised in very small steps, until the "knee" of the curve is reached; after this has been passed the rate of change in the voltage begins to decrease as the field cores reach saturation and consequently the current must be increased for a given increase in the voltage. After the current in the field has reached its greatest permissible value, it is reduced in steps and a similar series of voltage readings taken which, when plotted, will not coincide with those given by the increasing current but will lie above them. Any changes in speed are to be allowed for.

Care is taken to always change the current in the same direction; that is, while readings are taken for the first portion of the curve—with increasing field current—never to decrease the current until the peak of the curve is reached, and *vice versa* on the coming-down curve.

If, on examination of the curve, the rated voltage of the dynamo intersects well up on the "knee" the machine is in a stable magnetic condition; if the voltage intersects on the straight part of the curve any small derangement of the shunt-field current will cause an abnormal change in the magnetism and consequently in the terminal voltage.

As an incident, if the curve be compared with text-book saturation curves (such as Ewing's) for different metals, a fair inference may be drawn as to the material of which the field cores are composed.

XXVI. Field Compounding, or Armature Characteristic.

This test is made for the completion of record data of a new type, size, or style of generator and upon one of a lot; it will show the relative amount of magnetization produced by the series-field ampere-turns and, in the case of a new machine, when the number of turns on the shunt field is known, gives a direct determination of the turns required for the series field.

In this test the shunt field of the machine must be separately excited and the series turns left out altogether. The armature current is varied in steps from 0 to 150 per cent of the rated load and back again, the volts of each step being brought to the normal by varying the shunt-field current. Speed is kept as nearly constant as possible; readings of field amperes and load are taken at each step. The curve is then plotted.

The field current must always be varied in one direction as in the magnetization curve, changing it when the maximum point of the curve is reached.

The curve is plotted for field currents as ordinates and armature currents as abscissæ; the terminal voltage is maintained constant. It affords a means of determining the extra voltage due to the series field, and thus a check on a machine which does not compound well.

XXVII. Parallel Operation.

Generators of the same type and manufacture are to be capable of operation in parallel, the division of the load to be within 20 per cent throughout the range.

If several machines of the same kind are under inspection, it is necessary to test capability of operation in parallel. This is done at various loads, the loads being thrown on and off in steps, carefully noting whether the division of the load between the machines is within the specified limit of 20 per cent throughout the entire range up to full load.

XXVIII. Efficiencies.

Only the electrical efficiency is provided for in the specifications. The set efficiency is quite as important as it includes the engine performance as well, and is usually included in the test record.

a. Electrical Efficiency.—The minimum allowable efficiencies of the generators are as follows:

K.W.	LOADS.			
	$1\frac{1}{3}$ Per cent.	1 Per cent.	$\frac{3}{4}$ Per cent.	$\frac{1}{2}$ Per cent.
2.5	78	78	76	73
5	80	80	78	75
8	84	84	83	80
16	87	87	86	84
24	88	88	87	85
32	88	88	87	85
50	89	89	88	86
100	90	90	89	87

The electrical efficiency, the ratio of the generator output to the total watts generated in the dynamo, affords a practical criterion of the performance of the dynamo as compared with known percentage losses of high-class generators. At any load the output in watts, plus the core loss which is constant at all loads, plus the various C^2R losses, gives the input, from which the per cent efficiency is readily calculable.

The C^2R (or heat) losses are those in the armature winding, shunt winding, series winding, shunt rheostat, brushes, leads, brush contact, and series shunt.

The C^2R losses having been determined, it remains to derive the core and friction losses. The motor method is employed as it gives results which are sufficient practically, though lack of balance of the cranks is not separable by this method.

The connecting rods are cast loose from the crank pins that the crank shaft may revolve freely and a motor is belted to the fly wheel to drive the armature, the whole adjusted to permit no slip of the belt. When the motor is supplied with current and is driving the generator armature at its rated speed, part of the energy is dissipated as C^2R loss in the motor armature and field, etc., and the remainder is expended in turning the two armatures against frictional and other opposing forces; the losses due to these are equal to $CE - C^2R$. In which $C =$ current supplied to the motor armature; $E =$ the E. M. F. at the motor terminals, $R =$ motor armature resistance taken hot.

The result will contain the frictional losses in both machines in addition to the core losses, due to the magnetization of the generator; these frictional losses must be accurately determined and subtracted from the value obtained by the above formula for

each reading. The input into the motor when running at that number of revolutions per minute which will be necessary to drive the generator armature at its proper speed is very carefully determined.

When the motor has run until thoroughly warmed up, the belt is thrown off and the hot resistance of the motor armature is then taken; the test proper now begins. The motor is again belted to the fly wheel and the generator armature and crank shaft are driven at rated speed with the brushes off the commutator. The increased input consumed by the motor is now due to windage and main bearing friction of the generating set; this amount can be divided between the generator and engine proportionately to the number of bearings of each; the windage is not separated in the allotment. The brushes are next lowered on the commutator at proper running tension and the speed adjusted; the increase in input into the motor is chargeable to brush friction.

Current is next passed through the generator field, started at some low value and increased in steps up to the greatest permissible value and back again; at each step the speed is adjusted and the motor input noted; the increase of input is due to increase of core losses. Several sets of readings are taken which should check closely and from them a curve can be plotted and the required core loss obtained.

The following practical considerations are of service when this test is performed. The motor field is to be maintained constant under all conditions and as strong as is compatible with safety; the motor field loss does not then enter into the calculations; there is freedom from sparking; the armature current is small; the errors of adjustment and observation are to some extent lessened, and the motor core losses will be constant. It is preferable to use a motor with copper brushes; with carbon brushes the C^2R loss due to brush contact is widely variable.

b. Overall Efficiency.—The overall efficiency, also known as the commercial, net, or set efficiency, is the ratio of the indicated horsepower of the engine to the electrical horsepower output. It is more convenient to express the quantities in kilowatts and obtain the ratio in this way. The indicated horsepower is derived from the indicator cards taken for different loads, using a planimeter, the amperes and volts being noted for the time of taking the cards.

XXIX. Range of the Circuit Breaker.

When a circuit breaker is supplied with the generator it is usually dismounted and tested in the test room. It is then set for its different currents as shown on the scale, is read, and the current slowly raised to the value for which the circuit breaker should operate and the amperes noted for which it actually operates for that scale reading. The circuit breaker must not be so connected as to open the field circuit.

XXX. Range of Field Rheostat.

The total range of adjustment by the shunt-field rheostat is to be from 10 per cent above to 20 per cent below the rated voltage of the generator; the variation to be not more than one-half volt per step at both full load and half load.

The steam pressure being normal and the voltage at the rated value for no load, all resistance is cut out of the rheostat and the resulting voltage noted; all resistance is then put in and the voltage again noted.

Full load is next switched in, the voltage adjusted and the variation of voltage from block to block noted; the same operations are made at half load.

The intention is to avoid a rheostat of coarse graduations which would affect the lamp life. A convenient time for makng the test is at the time of taking the compounding.

XXXI. Interchangeability among the different sets and their spare parts, of the same size and make, as furnished in any one contract is required; this to be demonstrated as part of the final test for acceptance.

The engine is taken apart and examined for wear or scoring in bearing surfaces, particularly within the cylinder and valve chests and reassembled with the spare parts, and parts of other similar engines under test to ensure that they fit properly and are interchangeable. This is often in error and would occasion much inconvenience on board ship when one set is to be rehabilitated from another, or parts are to be replaced by spares from store.

The spare armatures are placed in position in the fields and are given the same tests as the armatures which are in place when the set is received.

Motors.

The items of inspection of a motor depend largely upon the specifications in the particular contract and these will vary for a given output; with the nature of the duty to which the motor is to be applied; the location of the motor as regards exposure to heat, dust, and moisture; whether the motor duty is to be continuous or intermittent; the nicety and range of regulation, etc.

The specifications may be separated into two divisions for inspection:

I. The mechanical and electrical features of the motor as a means of converting the electrical input at the brushes into mechanical work given out at the shaft, the machine being considered as a dynamo converting in an opposite sense.

II. The performance on a desired duty, or an examination into the efficiency of the application and control of the output at the pulley for the work to be performed.

Under I, therefore, the motor is tested as to its good mechanical construction and its efficiency of conversion of energy, and, under II, as to the prescribed performance on applied use.

The mechanical construction is exactly covered in specifications and test in this respect is made by examination of the separate items in the machine itself and from drawings.

Electrical and Operative Features.

The tests are to determine balance, heating, insulation, sparking, efficiency, etc., and, incidentally, the operation of any speed-regulating apparatus.

Balance.—I. The armature is to run true; II. The armature to be balanced mechanically and electrically.

The motor is first run as a generator before preparing for the heat run, and the electrical balance of the armature circuits is measured as for a dynamo.

Heating.—This is determined by a heat run of the motor at the rated output (full load), at the rated input (volts and amperes per name plate).

The permissible heat rise and duration of run varies in specifications for the various types of motors.

Heat Run.—For the heat run of motors (except ventilating motors) the motor is belted to a generator which thus independently supplies the load. The generator may be of a larger

size and of different voltage from that of the motor but should be preferably of the same size and voltage; a duplicate pair of motors is usually available, one to act as the motor under test, the other being driven as a generator by the motor. The generator is connected up to a load consisting of German silver rheostats as in testing dynamos; lamp banks or water boxes can be used, but cannot be as conveniently regulated.

The cold resistance of the motor armature and field are first measured and the motor is then connected to a supply circuit whose voltage must be higher than that of the rated voltage of the motor.

The starting box, controller, or controlling panel which is to be used with the motor is connected in the supply line and used during the heat run; it is first to be assured that the connections will cut in the field before current has access to the armature and will cut out the field only when the armature current has ceased.

Before starting, rheostats are connected in the armature and field circuits and short-circuited by switches. These rheostats can be quickly introduced by switches and can be quickly introduced after the heat run and the readings made for the drop with different current values without changing the source. The armature is measured with the field circuit open by disconnecting at one binding post of the field ammeter and opening the short-circuiting switch; the field is measured by opening the armature circuit in a similar way.

The motor is next started and brought and kept to its rated input of volts and amperes by regulating the load on the generator; the rated input, as developed in the factory test, is taken as giving the rated output; if the input is not known the motor losses are first determined and are added to the rated output to determine the necessary watts of input at the rated voltage of the machine.

Thermometers are placed on the motor frame; on the bearings; on the armature of a similar machine nearby if possible; in the air in front and back of the machine 3 feet from, and on a line with, the shaft; on the overload and no-voltage spools of the panel, and within, and near the center of, the controller casing.

The heat run is then started and continued for the prescribed number of hours. Readings are recorded every half-hour, if the run is greater than one hour, or every 15 minutes if for one hour

only. Portable instruments are employed and are carefully calibrated before starting the run. The voltmeters are kept out of circuit by cut-out switches, and the ammeters by short-circuiting switches, except at the time a reading is taken, to prevent injury to the instruments from heating and from sudden fluctuations or overload, and in the case of ammeters to keep the instruments from changing calibration.

Items of observation and report during the run are:

I. Motors are to be designed to operate on the voltage of the prescribed installation (now 125 volts).

II. All connecting pieces and other current-carrying parts to be so proportioned that no undue heating will occur when they are worked under the severest possible conditions.

III. All the field poles to be equally energized (electrical balance).

IV. The motor to be at least capable of developing the rated (specified) horsepower output for the total time of the continuous heat run.

V. The shaft and bearings of **turret motors** to be provided with thrust collars which will limit the end play to the smallest practicable, and which will stand a continuous end thrust at least twice in amount that developed by the gearing to be used and the maximum output of the motor without the collars heating or cutting.

VI. There is to be no sparking when running at the rated speed and output, nor must there be any injurious sparking on reversal. Some sparking usually occurs; if it is not a red or yellow spark, and retains the blue color, it is not detrimental.

At the expiration of the heat run the hot resistances are measured, the thermometer temperatures read, and the heat rises calculated as for a dynamo. The curve of rise for the field is plotted during the run. The various readings and measurements are similar to those for generators.

Insulation Resistance.—Two insulation tests are usually made as in the case of dynamo: the ohmic test in which the electrical circuits, including the control panel, are to show one megohm to ground and between circuits with a direct current at 500 volts; and the dielectric or rupture test in which the insulation is to stand the application of an alternating current potential of 1500

volts for one minute. These tests are made in the same manner as described for dynamos.

Efficiency.—This is specified for one-quarter, one-half, three-quarters, and full load, and is also tested for 25 per cent overload. The specifications prescribes "the highest commercial efficiency for the size and speed" and may be considered to vary at full-load ranges from about 73 per cent for motors of 1 horsepower to 85 per cent for motors of 10 horsepower, and up to 90 per cent for larger sizes. These estimates will be found to be well below those actually obtained for well-constructed commercial machines.

Probably the best method of determining the efficiency of motors is that in commercial use and known as "Stray Power" or "Loss" method, *i. e.*, determination of the various losses. The method is sufficiently correct for practical purposes, and avoids the difficulties attending methods necessitating the application of full load to the machine, and the measurement of the mechanical output. The Hopkinson method for full-load efficiency has objections and is probably less accurate than the "Stray Power" method.

The only data required, other than that already obtained, are core loss, windage, brush and bearing friction, and the total armature-circuit resistance, which includes the armature winding, brush contact, brushes, and leads to the terminals of the machine.

This data is obtained immediately after the temperatures are taken at the end of the heat run as follows:

(*a*) The total armature-circuit resistance is measured by the fall of potential method between the terminals of the machine. Current and voltage readings are taken in the same manner as in determining the resistance for the heating tests, except that the armature is turned to several positions, about five in all, with three values of current at each. From these 15 readings a good average value is obtained for calculating the C^2R loss in the armature circuit.

(*b*) The core loss (hysteresis and eddy currents), windage, brush and bearing friction are obtained in one observation.

The belt is removed, the motor started up, and the field current adjusted to the last value observed in the heat run (by the rheostats provided in the field and armature circuits). The armature will then be running under the same conditions as when carrying

full load, hot. Readings are then taken of armature volts and amperes. For the amperage a low-reading ammeter is used (corresponding to the small current) but of sufficient range to give a sizeable deflection. The product of these two readings, less the C^2R loss in the armature circuit, gives the required losses.

The other losses are obtained by calculation. The C^2R loss in the field is calculated from the hot resistance measured for the temperature rise at the end of the heat run and the current as shown in last reading in the heat run; this loss remains constant for all loads. The C^2R loss in the armature circuit is obtained from the measured resistance and the armature current for the particular load.

The sum of all these losses deducted from the input give the output. The efficiency is computed as the ratio of the output to the input, both in the same notation.

The method neglects:

(*a*) Additional friction loss in bearings due to increased pressure caused by the pull of the belt; this should not properly be charged to the motor as it does not appear in direct-connected machines.

(*b*) Iron losses in pole tips when the machine is loaded. This is small in modern machines using laminated pole pieces.

(*c*) Iron losses in armature core due to the constantly reversing current in armature winding.

(*d*) Changes in core loss, due to reduction of the flux by the back-ampere turns when the motor is loaded.

The foregoing losses are so small that they may be considered negligible in practice.

Speed Regulation.—For constant-speed motors the variation in speed from no load to full load is not to be more than 9 per cent in motors of less than 5 horsepower, and not more than 6 per cent in motors of 5 horsepower and above. This is determined by direct observation by a tachometer, noting the speed at no load, one-quarter load, one-half load, three-quarters load, and at full load. The machine should be hot when the observations are taken.

Ventilating Fan Motors.—While motors of this type are given a heat run test at the factory when separate from the fan, the motor and fan assembled together is the usual method of delivery for test.

Strictly speaking, the heating determination requires two separate tests for the full time of heat run; one, with full voltage on the field (lowest speed) for the actual field heating on this duty; the second, with a full rated current on the armature and weakened field (highest speed) to determine the highest heat rise of the armature.

The test is ordinarily made as to heating, etc., when driving on open exhaust on the "hold up" in lieu of free exhaust. The hold up is accomplished by attaching to the fan outlet (or nozzle) a duct whose length is 48 inches, whose larger diameter in inches is that suitable to fit the fan outlet and whose smaller diameter is determined (by a factor for the particular type of fan) from the "hold-up area" in square inches; this area is equal to $\frac{DW}{3}$ in which D is the diameter of the fan wheel and W is the width of the wheel, both in inches; the factors for various sizes are as follows:

TABLE FOR TESTS OF EFFICIENCY REQUIRED FOR ELECTRIC FANS WITH CAST IRON SHELLS AS PER U. S. STANDARD SPECIFICATIONS.

Curved Float Wheel.			Full Outlet.				$\frac{DW}{3}$ Outlet.				Weight.
No.	$\frac{DW}{3}$	R.P.M.	Vol.	H.P.	K.W.	Press.	Vol.	H.P.	K.W.	Press.	
	Sq. in.		*Cu. ft.*			*Oz.*	*Cu. ft.*			*Oz.*	*Lbs.*
		1285	296	.072	.053	0.25	197	.055	.035	0 50	
1	9.32	1820	420	.205	.153	0.50	280	.155	.115	1.00	
		2230	512	.381	.284	0.75	342	.285	.212	1.50	
		1140	429	.105	.784	0.25	285	.079	.059	0.50	
2	13.5	1620	608	.300	.224	0.50	404	.225	.168	1.00	215
		1980	740	.555	.414	0.75	494	.418	.312	1.50	
		900	604	.149	.111	0.25	403	.112	.087	0.50	
3	19.0	1350	867	.420	.312	0.50	578	.315	.235	1.00	337
		1650	1040	.780	.572	0.75	695	.590	.440	1.50	
		800	833	.204	.152	0.25	555	.153	.114	0.50	
4	26.3	1170	1178	.579	.432	0.50	785	.435	.322	1.00	513
		1390	1450	1.080	.806	0.75	967	.815	.607	1.50	
		700	1052	.260	.194	0.25	702	.195	.145	0.50	
5	35.2	994	1480	.740	.552	0.50	987	.555	.413	1.00	
		1220	1815	1.370	1.022	0.75	1270	1.026	.726	1.50	
		595	1846	.460	.343	0.25	1230	.350	.261	0.50	
6	58.7	842	2620	1.300	.970	0.50	1765	.980	.73	1.00	
		1000	3235	2.400	1.79	0.75	2150	1.800	1.340	1.50	
		520	2660	.650	.485	0.25	1770	.490	.365	0.50	
7	85.3	736	3720	1.830	1.36	0.50	2488	1.380	1.028	1.00	1050
		902	4680	3.410	2.54	0.75	3040	2.560	1.910	1.50	
		452	3605	.890	.664	0.25	2400	.670	.506	0.50	
8	113.7	640	5100	2.510	1.87	0.50	3400	1.88	1.400	1.00	
		784	6250	4.640	3.46	0.75	4165	3.500	2.610	1.50	

Operation on Required Drive.

The ability of the motor to operate on the use to which it is to be applied is tested, as far as practicable, by handling weights at the works of the contractor under the action of its own controlling apparatus, rheostats, and connections; but its final test is specified to be made after installation on board ship in the position and location in which it is finally to be employed, and the details depend on the items of specifications for the particular case. The following are given as examples:

Turret-Turning Motors.—When the installation of turning gear is completed on board ship the completed turret is to be turned from extreme train on one side of the vessel to extreme train on other side, and a stop made as each abeam position is reached (the turret being started again immediately after being stopped), the speeds and accelerations being the maximum, the control of the turret to be maintained throughout the full arc of fire as follows:

Turrets are to be able to be turned at a maximum rate of 100 degrees of arc per minute, and at a minimum rate of about ¼ degree per minute.

The turret is to be able to be accelerated at such rate that it can be started from rest and brought to within 10 per cent of its full speed of 100 degrees per minute in 10 seconds of time, and while turning at its full speed to be able to be stopped in 5 seconds of time.

This cycle of operations is to be continued for a continuous period of one hour, without the temperature rises as follows: each motor to be tested by running it for a continuous period of one hour at rated horsepower and voltage without increasing the temperature of the series field more than 70° C., the commutator 65° C., the armature and any other part 60° C., above the surrounding air. The shunt windings to be able to carry full current continuously for 2 hours without increasing their temperature more than 50° C. above the surrounding air. If the system of control is such that maximum heating occurs at a speed other than the maximum, a similar test to be made at speed corresponding to the maximum heating effect.

The turret will also be operated on each controller notch a sufficient number of times to demonstrate satisfactory working.

When actually turning a turret on board ship the two motors

must equalize their load within 10 per cent of full-rated load when running in series or parallel (according to system used) at all speeds and directions.

Ammunition-Hoist Motors.—One ammunition-hoist equipment complete with controller, rheostats, circuit breakers, etc., is considered as typical of a set of similar equipments and is subjected to the following tests:

A weight of 4000 pounds is hoisted and lowered continuously during one hour; starting with its weight supported by the lower stop, hoisted 50 feet, then lowered till its entire weight is supported by the lower stop. The total number of feet traveled by the load during the hour is not to be less than 12,000, and the elapsed time of hoisting or lowering from start to stop not to exceed 10 seconds.

At the completion of the test the temperature above that of the surrounding air shall not exceed the following: Series-field windings, 70° C., measured electrically; shunt-field windings, 50° C., measured electrically; commutator, 65° C., measured by thermometer; armature or any other part of the motor except bearings, 60° C., measured by thermometer; bearings, 40° C., measured by thermometer.

The motors are to be capable of carrying an overload of 50 per cent for 5 minutes without appreciable sparking or overheating, and a momentary overload of 100 per cent without injury.

The motors are to be fitted with such braking device that the load will not fall when the controlling lever is in any position, no matter what variation of current or voltage may occur; this braking device is to be capable of holding a load of 4000 pounds.

The following is the method pursued in testing desk and bracket fans:

Test of a New Type of Fan Submitted for Approval as to Type, Construction, and Performance.

The fan, which is rated at ⅙ or 1/12 horsepower, and of either the bracket or desk types, is first taken apart and a rigid inspection made.

The electrical test necessitates the bringing out of a special circuit from the junction of the rheostat in the base and the field coil in order to obtain the drop across the field which will be

taken between the circuits just described and the brush terminal at which the field and armature join.

The cold resistances of the field coil and armature are first taken; that of the latter being taken by holding two sets of 2-pointed terminals, one for current and one for drop, across commutator bars diametrically opposite, taking the reading of the current and drop; this operation is repeated for several sets of commutator segments, care being taken to select bars diametrically opposite, and taking comparative readings on the same bars. The average of these readings is taken as the cold resistance.

The fan is then started up and the cold resistance of the field coils immediately taken. The line voltage, current, and drop across the field is taken every 15 minutes until the fan temperature has reached a maximum when the fan is stopped and the armature resistance (hot) is taken in the same manner as the cold resistance was taken. From the hot and cold resistances heat rises are calculated as for dynamo windings.

After this is finished the fan is carefully re-assembled (or another of the same kind is taken if several of the same types are submitted for the heat run) and is then subjected to a life test. This test shows the ability of the fan to operate over long periods with little or no adjustment and consists of a 500-hour continuous run, during which readings are made of volts, amperes, speed, air velocity, temperature of room and of motor frame. Volts and amperes input are ascertained in the usual way.

The speed readings present the difficulty that no speed counter or tachometer can be applied to the shaft as these cause a pressure on the shaft and cause the fan to absorb more power or will cause a marked change in speed; the stroboscope is therefore employed to check the speed. The stroboscope consists of a metal disc in which four openings, about the size and shape of fan blades are cut; this disc is rotated by a motor, a tachometer being directly connected to its motor shaft. If now the disc be rotated with constantly increasing speed and the revolving fan be observed through the openings of the disc, the fan blades will seem to run or move more slowly as the speed of the disc approaches that of the fan, until, when the fan and disc are revolving at the same speed the fan will appear to stand still; the tachometer connected to the stroboscope shaft is now read and gives the number of revolutions per minute of the fan.

The air velocity of the fan is read by means of an anemometer placed one foot in front of the plane of revolution and moved in a line at right angles to the extended line of the shaft until the highest reading is obtained; this will determine the maximum velocity of air discharged at full speed which is specified at 1200 feet per minute for a 1/12-horsepower fan and 1500 feet per minute for a 1/6-horsepower.

A close following of specifications should permit no adjustments to brushes, lubricating devices, or bearing during this run; but should a fan stop due to some minor or easily remedied defect, such as a poor brush, this would be remedied (noting the circumstances) and the run finished.

Upon the competition of the life test an insulation test is made on the assembled fan which must show at least one megohm measured with 500 volts applied one minute, after which the fan is taken apart and examined for wear of shaft and bearings, condition of commutator, armature, field brushes, etc.

Test of a Fan of Approved Type.

Each fan is subjected to a 4-hour full-speed run, during which readings are taken at the beginning and at 1-hour intervals for determining heating, watts input, speed by stroboscope, and velocity (maximum) of air discharge. At the end of the 4-hour run an insulation test is made. All of these observations are taken by the same methods as pursued in the life tests of a fan submitted for approval.

The air velocity formula used is:

$$V = 940\ (459.4 + t)\ \frac{h}{B}.$$

t = temperature of fan air in degrees Fahrenheit.
h = inches of water in pressure gage.
b = barometer reading in inches of mercury.
V = velocity in feet per minute.

This formula corrects to a standard room temperature of 50° Fahrenheit, and for a barometer reading of 29.92 inches and uses a coefficient of discharge for a conical mouth piece of 0.98.

CHAPTER XI.

AUXILIARY APPARATUS AND INSTRUMENTS USED WITH GENERATING SETS AND MOTORS OR FOR TESTS.

Reducing Valve.

There are three types of reducer in use, but none are advised to be installed in other than a horizontal position as the valves are likely to chatter and the steam pressure to oscillate.

Foster, New Class W Valve.—The construction of sizes of 2½ inches and over, is shown in cross-section in Fig. 211.

A.—Inlet. *B.*—Outlet, when used as a straightway valve. *C.*—Outlet, when used as an angle valve. *D.*—Diaphragm chamber. *E.*—Steam-port, connecting valve chamber with diaphragm chamber. *F.*—Diaphragm. *G.*—Valve-stem. *H.*—Double-seated valve-clapper. *K.*—Nut for regulating discharge pressure. (Turn to the right to increase, and to the left to diminish pressure.) *M.*—Port screw for closing or partly closing off steam from diaphragm chamber.

A slot in the head of the port-screw indicates the direction of port in the sizes of 2 inches and under. The regulator being in a vertical position, the port-screw is open when the slot is vertical. Port-screws having no slot in the head (used on valves 2½ inches and over) are closed by turning the screw to the right as far as it will go.

The regulator is provided with a balanced valve, constructed to insure a tight seating under all conditions of temperature and pressure. The body of the valve is so made that the inner and outer castings are connected with expansion-resisting webs, which carry off the heat by radiation equally on all sides, and thus prevent distortion of the seats out of true. Elongation of the neck between the two clappers is compensated for by making the upper seat almost flat, and the lower seat nearly straight (15 degrees off the vertical line). By this means the upper seat is brought to its bearing by force of the delivery pressure acting on the diaphragm, while the lower seat finds its bearing by diametrical expansion.

The power to resist the closing of the valve is secured by interposing toggle-levers between the diaphragm and the spring. The increasing power of the spring as it is compressed is compensated for by the increasing power of the toggle-levers as they come into line.

Before attaching the valves blow out the pipes thoroughly; after the valve is attached blow steam through it in order to carry away lead, cuttings, or other foreign substances that may have lodged on the valve seats. Do not use red or white lead to make pipe joints; use oil, or Dixon's Pipe-Joint Grease.

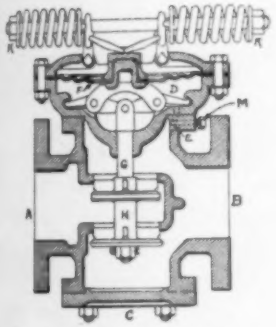


FIG. 211.—Foster new class W reducing valve.

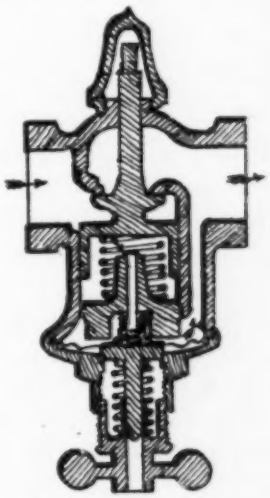


FIG. 212.—Curtis reducing valve.

A strainer should be attached directly to the inlet of the regulator and should be thoroughly cleaned beforehand.

The steam must pass through the regulator in the direction indicated by the arrow cast on the side of the body. The outlet may be either at *B* or *C*.

When making connections to the regulator, the pipes should be cut and the fittings made up in such a way as to avoid any strain on the pipe or regulator. When possible, use an adjustable hanger on each side of the regulator to relieve the stress.

After all connections are made and while steam is passing through the valve, regulate the delivery pressure by turning the

spring nut *K* to the right to increase, and to the left to diminish, the discharge pressure or volume.

If there should be violent pulsation of the diaphragm when delivering steam to an engine turn the screw *M* slowly to the right until only a slight movement is perceptible—exactly as a steam-gauge is throttled to prevent the hand from vibrating; attention to this important matter will prolong the life of the diaphragms. If the valve "chatters" turn the screw slowly to the right until the noise ceases.

When delivering steam to an engine, or a pump, locate the regulator as far from the steam-chest, or engine, as the piping will admit. As a rule, the cubical contents of the pipe between the regulator and the steam-chest should be as great as that of the steam cylinder; this provides a cushion which prevents a constant movement and wear of the valve.

Curtis Pressure Regulator.—The construction is shown in cross-section in Fig. 212.

It is to be located in an upright position in a horizontal pipe and in some place where it can be easily got at. The steam should flow in the direction of the arrow on the side.

When ready to start the regulator first turn back the handle on top, until all pressure is removed from the spring, then turn on the high pressure. If in order the regulator will open for a few seconds (until the chamber over the piston fills) and then close, shutting off all pressure beyond it. Next open wide the globe valve, between the regulator and the high pressure, then turn down on the handle of the regulator until the valve opens, and continue turning down slowly until the desired pressure is reached. A slight turn of the handle either way will alter the pressure and when once set a uniform pressure will be maintained. If the regulator should fail to close when the handle is turned back and taken out, it will be on account of dirt. If the pipes are new or recently put together, blow steam through for some hours before opening the regulator; this will blow out the dirt and red lead and dry up the oil on the inside of the pipes.

To open the regulator for examination, first turn off the handle on top and take out the spring under it; remove the cap, taking care to slide it off sideways, with the hand under the diaphragm to keep it in place. Unscrew the cap inside by means of the square top, then remove the spring and valve under it. If the

valve sticks it can be pushed up by the stem projecting through the bottom.

See that the set, valve, piston, and stem are clean and free from all dirt and chips, or iron or brass, and the hole in the piston (about the size of a pin) clear. Slip off the spring ring carefully, and if the valve does not drop freely into its seat (when perfectly clean) take it out, reverse it, and try the piston bottom side up; also try the stem by reversing the piston and pushing the stem up from the bottom. Wipe the stem perfectly clean; if it is cut polish it with fine emery paper and wash out all of the emery. If in order the valve should drop freely into its place on its seat like a check valve and be perfectly free when everything is hot.

Before replacing the inside cap, see that the secondary valve (in it) is free from dirt and perfectly tight. Screw the inside cap to its seat and close up the regulator by putting on the outside cap (containing the diaphragm and follower) and screwing it firmly to its seat, thus making a steam-tight joint without the use of lead. There should be no dirt on the top of the regulator where the diaphragm makes its seat and the diaphragm should be clean; such a joint is not likely to leak. The diaphragm goes in with the bead up. Next open the stop valve wide and turn down on the handle of the regulator to start.

The working of the valve can be seen by taking off the acorn at the bottom; little steam will escape.

The Leslie Pressure Regulator.—The type (Fig. 213) proves very satisfactory in service and is especially efficient when frequent changes of steam pressure are required as in test work. All Leslie high-pressure regulators, Class E, are made of U. S. Government composition.

The main valve *D* is held in position (when not in operation) by the spring *E*. It is convexed to insure greatest possible strength and is so guided at all times, increasing its life and efficiency. It is actuated by the spring *E* by the initial pressure, being opened by the initial pressure on top of the piston *F*, and closed by the spring *E* and the initial pressure under the main valve *D*.

The piston *F* is actuated by the initial pressure and the spring *E*; the initial pressure is admitted on top of piston *F*, from the port *S*, through a controlling valve and port and is counteracted by the initial pressure and spring *E* against the bottom

of the main valve *D*, the stem of which is fitted into the piston *F*; both main valve *D* and piston *F* operate simultaneously and are controlled by the controlling valve. The piston *F* is fitted with spring rings and is protected from dirt from the boiler by having no flow of steam through the cylinder. The dirt will follow the current and pass out with the delivery flow.

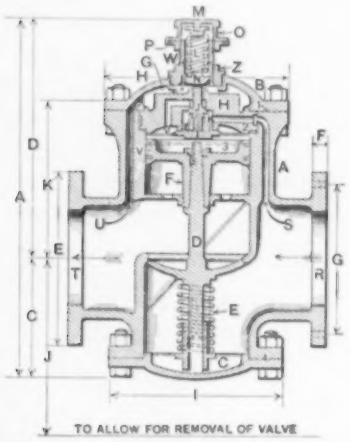


FIG. 213.—Leslie reducing valve.

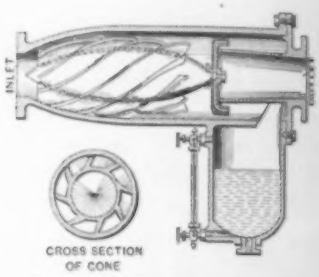


FIG. 214.—DeReycke separator.

The controlling valve is held in position (when not in operation) by a spring. It is opened by screwing down the adjusting cap *O* on the adjusting spring which forces the diaphragm *G* down on the stem of the controlling valve and opens the latter, allowing the initial pressure to pass through from the port *S* into the port *V*, to the top of the piston *F*; the reduced pressure enters the port *U* on the delivery side and acts on the diaphragm *G*, balancing the action of the adjusting spring; as the pressure tends to decrease under the diaphragm *G*, the controlling valve and the main valve *D* open proportionately more, until equilibrium exists between the pressure that the adjusting spring is set for, and the reduced pressure under the diaphragm *G*. The size of the diaphragm *G* is the same in all regulators from ½ to 1½ inches. The adjusting spring will give a range of pressure from zero to 85 per cent of the initial pressure, up to 250 pounds per square inch.

The adjusting caps *O* are made to be adjusted with a spanner wrench; they are held in position by the lock nut *P* and can be

positively secured in position by a lock so that they cannot be tampered with.

The regulator must be placed in a vertical position, so that steam will pass through in the direction indicated by the arrow cast on the side of the body. The regulator should preferably be placed as near the boiler as possible. *A stop valve must be placed on the inlet pipe.*

Graphite or oil is to be used for making up pipe joints, never white or red lead, cement, or any kind of gum.

To set the regulator: first unscrew the adjusting cap *O* by turning to the left until the tension is entirely off the adjusting spring (a small spanner wrench is furnished to fit the adjusting cap *O*) then open the stop valve or drain pipe on the delivery side to allow condensation to pass off freely; then open the stop valve on the inlet side very slowly until it has been opened full; then screw down the adjusting cap *O* very slowly by turning it to the right, a fraction of a turn at a time (to give ample time to get rid of condensation and to thoroughly heat up), until the desired pressure on the delivery side is obtained, when the locknut *P* should be set up tight against adjusting cap *O* to hold the latter securely where set. It is important when setting to see that sufficient flow of steam at the initial pressure is obtained.

Where extensive piping is used, or in places where considerable water from condensation is likely to flow back to the regulator, the water should be trapped off before it reaches the regulators; the regulator will make a noise while the water is passing through and may also act as a water ram on the piston until it has forced the main valve open sufficiently to allow the pressure on the delivery side to increase to almost the initial pressure; this is apt to force sediment or other foreign substances into the working parts.

If a regulator should become sluggish and not recover quickly, especially on new ships, the trouble may be due to gum, lead, or other cement from pipe joints in the working parts which has baked on, particularly so on the seat of either the controlling or the main valve.

Working parts and inside the cylinder should be cleaned with kerosene and a cotton rag. If lead, pitch, or gum should get into the piston ring or grooves, the piston should be placed in a pan or bucket of kerosene and the rings turned around in the grooves

until the obstruction has been entirely dissolved; then stand it on edge for a few minutes to allow the dissolved matter to drain out, after which wipe off dirt and oil; when kerosene is used for cleaning, parts must be wiped off dry before being assembled; both valves and seats should be examined carefully to see that the valves seat properly all around.

Separator.—Two types are usually installed, the De Reycke and the Stratton.

De Reycke Separator.—The construction is shown in cross-section in Fig. 214.

The separator consists of a shell or casing in which there is firmly secured a stationary double-ended cone. On this cone are cast a number of knife-edged wings, extending spirally along its exterior, the annular space between the cone and the shell of the separator being equal at its smallest cross-section to that of

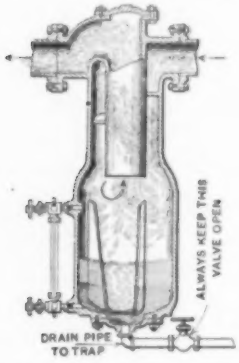


FIG. 215.—Stratton separator.

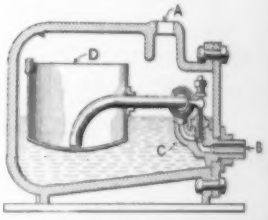


FIG. 216.—Dinkel steam trap.

the steam pipe; from thence it is greatly enlarged. At the outlet end of the shell there is an annular space, formed by an inwardly extending outlet pipe. On entering the separator the steam is spread and thrown outward by the cone and given a centrifugal motion by the spiral wings. These wings are constructed with curved surfaces tangential to the cone; this materially aids in producing an outward flow of the water. Steam on entering the separator is immediately expanded from a solid volume (due to the size of the pipe) into an annular space of equal volume, whereby its particles are removed farther from the center, and receive a greater amount of centrifugal force. Under these conditions the entrained water meets curver angular wings along

which it flows outward to the shell of the separator, and is collected in a well; here it is entirely isolated from the flow of the dry steam, which passes off through the outlet.

Stratton Separator.—The separator (Fig. 215) is based on the principle that, if a rotative motion is imparted to the steam, all the liquid particles it may contain, being heavier than the steam, acquire centrifugal force and are projected to the outside of the current.

The separator consists of a vertical pear-shaped (or cylindrical) casing with an internal central pipe extending from the top downward for about half the height of the apparatus leaving an annular space between the two.

A nozzle for the admission of the steam is on one side, the outlet being on the opposite side or on top as may be most convenient in making the connections. The lower part of the apparatus is enlarged to form a receiver of considerable capacity, thus

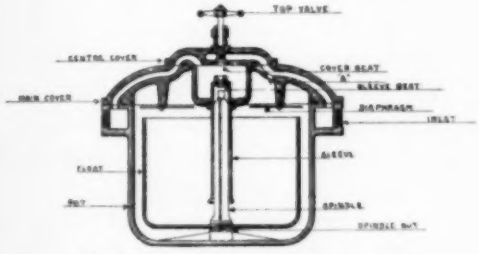


FIG. 217.— Nason steam trap.

providing for a sudden influx of water from the boiler. An opening is tapped at the bottom for a drain pipe to the trap whose valve should always be left open. A glass water gauge shows the level of the water.

The current of steam on entering is deflected by a curved partition and thrown tangentially to the annular space at the side near the top of the apparatus. It is thus whirled around with all the velocity of influx, producing the centrifugal action which throws the particles of water against the outer cylinder which has wings or plates projecting inward and standing at an acute angle to the course of the current, thus breaking up the whirling motion, and allowing the water to settle quietly to the bottom, whence it passes off through the drain pipe.

Pressure Gauges.—The type of steam and vacuum gauge is

the ordinary adaption of the Bourdon principle, known as the Ashcroft gauge; the dial face is 5½-inch diameter.

Steam Trap.—There are two varieties in use, the Dinkel and the Nason.

Dinkel Steam Trap.—The construction is shown in cross-section in Fig. 216.

A is the inlet; *B*, the outlet; *C*, the valve; and *D*, the copper bucket.

This trap consists of an open float bucket, lever attachment, and trap valve, all contained in a casting. The valve is held closed by the pressure in the chamber and opened by the increased power from the lever attachment. The trap shown is for a steam pressure of about 160 pounds. All the working parts are inside of the trap-chamber and are connected to the cover; in cleaning or repairing the working parts are removed with the cover.

The operation of the trap is as follows: As the chamber fills with water the bucket floats and rises until it strikes against the top of the chamber and can go no further, the water continues to rise until it flows over and fills the bucket, causing it to sink to the bottom of the chamber; the weight of the bucket is such, that by its operation the valve is opened, the water in the chamber above the top of the bucket and the water in the bucket, is then discharged, the bucket rises until it floats again and the discharge valve is closed. The valve is so arranged that a body of water is always left above the valve seat after each discharge, consequently steam cannot escape as it cannot be forced through the water.

The amount of water delivered at each discharge depends on the size of the trap-chamber. The time required for each discharge depends on the pressure in the trap-chamber.

To ascertain whether the trap is working open the air-cock; if water escapes, it shows that something prevents the trap from delivering, but if steam escapes it shows that the chamber has not yet filled sufficiently to cause the bucket to drop to the bottom of the chamber and open the delivery valve. As soon as steam comes from the air-cock close the cock and keep it closed.

Nason Steam Trap.—The construction is shown in cross-section in Fig. 217.

A cast-iron reservoir, or pot, is closed with a cover provided

with two cored passages and contains a float which is fitted with a spindle for its guide. A housing or sleeve is screwed centrally into the under side of the cover and within it the float spindle fits snugly, permitting, however, a short vertical motion. The top of the float spindle is ground flat and its upward movement is arrested by coming in contact with a bronze plug having a central opening, the two surfaces thus constituting a discharge valve for the trap.

One of the cored passages in the cover, is for the discharge of water from the trap after passing through the main valve, and the other serves as a by-pass, to permit any large volume of air or water to be blown through, when starting, without going through the cylinder and discharge valve. A valve (not shown) located externally in the cover gives entire control of this action.

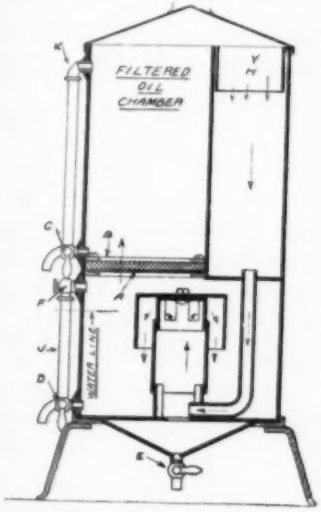


FIG. 218.—Hall Fitter.

Care should be taken that the trap is in all cases placed below the surface from which water of condensation flows. The discharge enters at the point marked "Inlet," and passing through the hole "A" into the body of the trap, a diaphragm above the float diverts the water of condensation into the pot, where, gradually rising, it first raises the float, thereby closing the discharge valve, and then, after reaching the top of the float, the water flows into it. When the float has nearly filled, its weight overcomes the tendency of the discharge valve to remain closed,

being held there by steam pressure, and the float drops to the bottom, opening the valve. Acting on the surface of the water the steam pressure immediately drives it up through the sleeve, discharge valve, and thence by way of the cored passage to the outlet. When the float has nearly emptied it becomes so light that it is again raised by the water about it, closing the valve, and the operation is repeated. This action is purposely intermittent, necessitating that the valve shall be either wide open or completely closed; the life of the valve is thus prolonged, and it will remain tight for a longer period.

The trap has no motive power within itself, and is not a return trap; water must run into it by gravitation and the discharge should ordinarily be into the open air or a hot-well.

Waste Oil Purifier.—*Hall Waste Oil Purifier and Refilter.*—The apparatus (Fig. 218) consists of a tank of galvanized iron divided into four compartments by galvanized-iron partitions; an oil receiver, the washing compartment, a false bottom, and a chamber for the filtered and cleaned oil.

The oil to be cleaned is poured into the strainer box *H*, which has a bottom of fine brass mesh, straining the oil in its passage to the receiver. From the receiver the oil passes by a pipe to a cylindrical receiver located in the large water compartment in the base, which compartment is filled with water to the level shown, and the oil is washed in its passage through the water in passing through *A* into the filtered oil chamber above *B*. The sediment settles into the false bottom and is drawn off at *E*.

To the top of the distributing chamber is strapped an annular cap which spreads the oil and water coming from *H* and thus acts as a separator.

At *A* and *B* is an assemblage of filter pads held between two strainer plates and a large mesh and secured against a flange of the bottom by follower rings, stud bolts, and nuts. A glass gauge shows the height of clean oil and is fitted with a stop-cock *C* by which the filtered oil can be drawn off for use. A glass gauge *I* shows the height of the water level; the level can be maintained by drawing off the excess water through the stop-cock at the bottom of the gauge.

When starting, clean the apparatus thoroughly, especially the compartment for filtered oil. Place the filter pads and screw the follower ring tight; the pads are a species of Canton flannel with

a nap on both sides, two are generally used but if oil can be passed in sufficiently large quantities it is better to use three or four pads. See that the bottom cocks of the gauge glasses and the emptying cock of the false bottom are closed to air. Pour water (preferably warm water) into the strainer box *H* until the water lever is up to the level mark. Next pour the dirty oil into *H*, two quarts at a time, until it appears in the bottom of the clean oil compartment, after that keep *H* full.

The pads should be cleaned by washing with soap at least once a month; if the filtered oil appears dirty put in new pads and clean the clean-oil chamber. If the oil to be cleaned is very dirty place a piece of canvas in the bottom of the strainer box *H*.

The water should be kept to the marked level.

The gauge glass cocks are three-way and can be closed tight should the glass be broken.

Switchboard.—There is so much variation in makes and types of switchboard in use, varying in construction with the number and sizes of generating sets installed, that no general rule can govern; but distinction is made between what is known as the *Standard Switchboard*, for three or more generating sets of 50 k. w. or 100 k. w. capacity—or a mixture of them—and the *Special Switchboard* for two generating sets of less than 50 k. w. capacity; it being generally contemplated that the latter type is not required to distribute to power circuits, or that the small amount of power to be used does not require any especial consideration and can be supplied by switches similar to those for the lighting distribution.

The Standard Switchboard.—The available space in a dynamo-room does not admit of that most convenient arrangement of having the distribution board in extension to the connections to the generating sets, thus having but one general board, and utilization of space requires the division of the switchboard entire into two sections: the *generator*, or *dynamo-room, board*, located in the dynamo-room, and the *distribution board*, located in a compartment near or contiguous to the dynamo-room; a similar arrangement being made for both the forward and after dynamo-rooms.

[NOTE 30.—A more recent arrangement is to have but one dynamo-room in the vessel and assign two distribution-rooms, one at either end of the ammunition passage and amidships: the forward of these contains the

dynamo-room switchboard as well, from which direct connection will be made to a distribution board in the forward distribution-room for all electrical energy required in the forward half of the vessel, and to the after distribution-room for all of the remainder.]

The Dynamo-Room Switchboard.—The front view of a board for four 100 k. w. dynamos is shown in Fig. 219, and the diagram of connections (panels reversed as compared with Fig. 219) in Fig. 220.

There are three panels (Fig. 219). Each panel is of 1½-inch slate, the face being enameled; the material is a good insulator and is preferable from the diagonal nature of its cleavage when fractured, thus forming a better temporary restraint from those short circuits which would be occasioned by the contact of the loosened through-bolts than is assured by a break in marble; enamel prevents the absorption of oil and water and gives a finish.

The middle panel accomplishes all necessary functions in relation to the actual machine connections and contains, from top to bottom (see also Fig. 220):

1. Four circuit breakers of 1200-ampere capacity which form the connection for the positive lead of each of the four dynamos separately.

2. Four ammeters, of the shunt type, one in each positive lead of the four dynamos.

3. Four voltmeters, each connected from the positive lead of the particular dynamo with which it is associated to the common negative bus bar.

4. Four hand wheels adjusting the individual shunt rheostat of each of the four dynamos. The hand wheel is furnished with a pointer in front of the board showing the stops or blocks passed over from "High," when the rheostat connects in least resistance in series with the shunt field and the dynamo is developing highest practicable terminal voltage, to "Low," when all practicable resistance due to the rheostat is in series with the shunt field and the terminal voltage is lowest. The hand wheels are mounted on a shaft which turns the lever of the shunt rheostat; the last named is usually mounted well to the rear of the back of the switchboard, preferably higher up; in this case a sprocket chain gear is assembled with the shaft and rheostat lever.

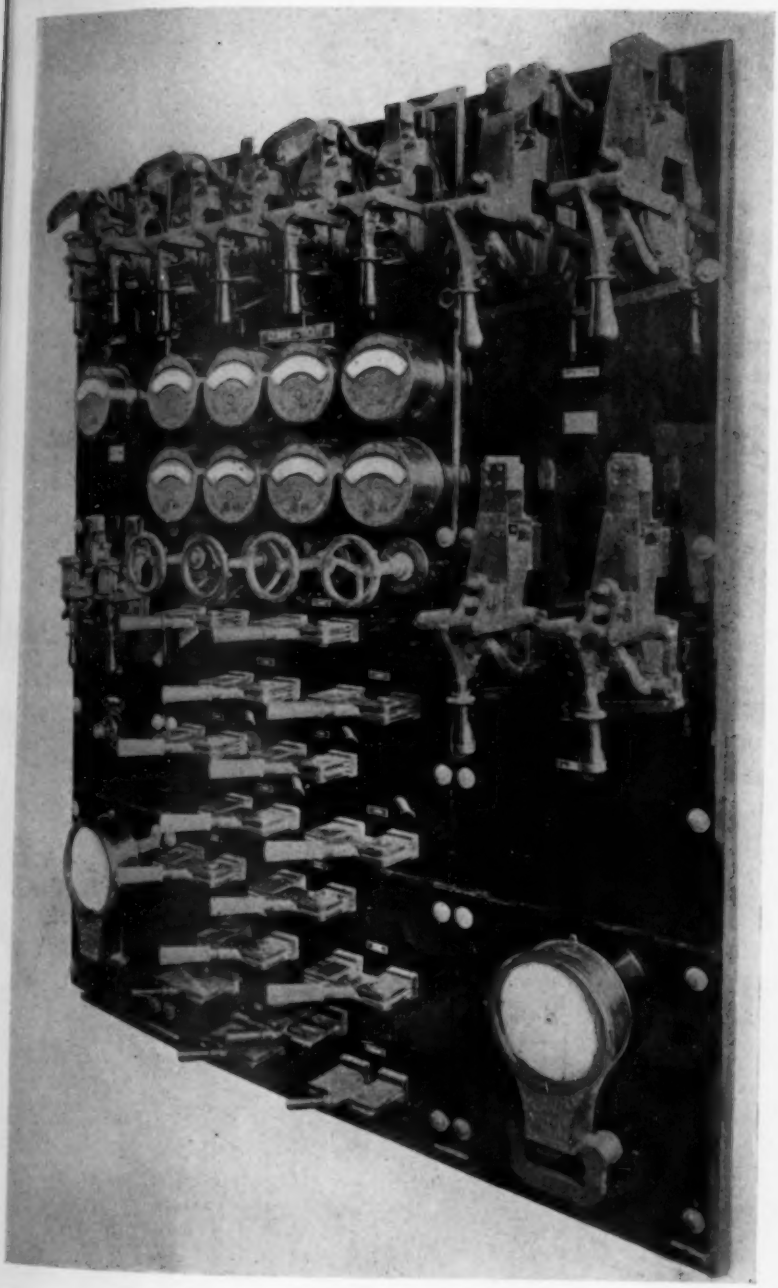


FIG. 219.—Dynamo-room board (Connecticut).

5. A set of single-throw knife switches of 1200-ampere capacity mounted in four rows of two switches each, the switches of succeeding rows being staggered for convenience of operation. The four switches of the two upper rows, one each for each dynamo of the dynamo-room, are connected through the board to

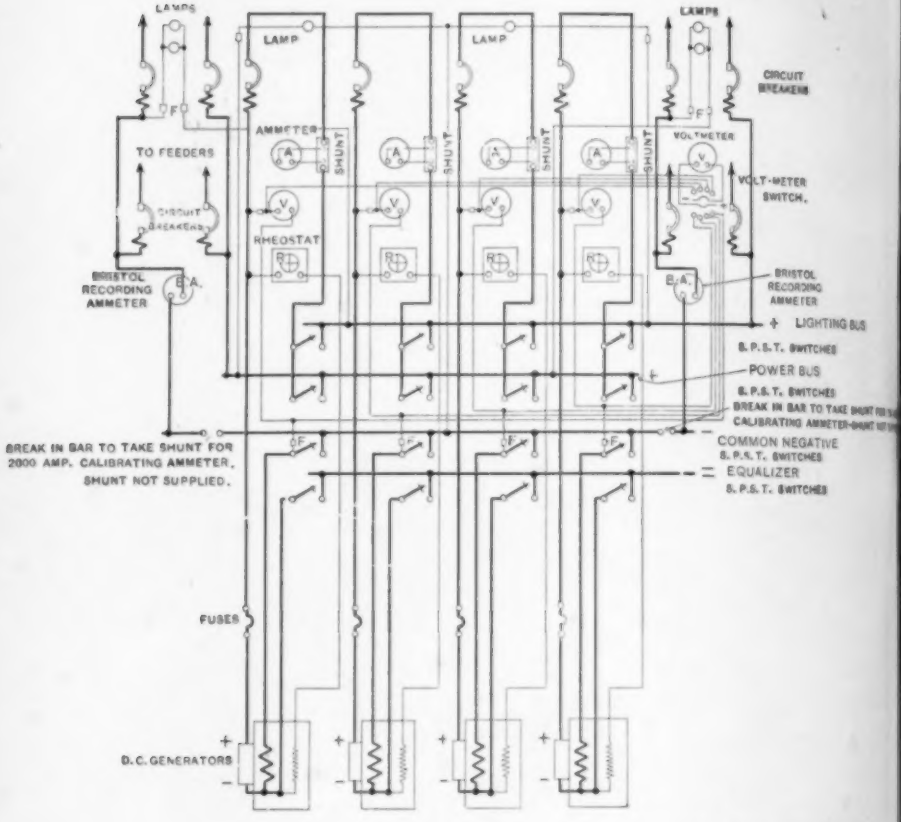


FIG. 220.—Connections dynamo-room board (Connecticut.)

a heavy copper slab running across the back of the panel set off from it by studs, and forming the positive bus bar for all energy to be taken off for distribution under the classification of "lighting"; in order to distinguish these lighting switches *their wooden handles are painted red.*

The four switches of the next two rows are for switching off energy to the positive bus bar of the "power" division, and are

similarly connected through the board to a heavy bus bar set off the back of the panel by studs and farther off than the bus bar for lighting. The switch handles for power *are painted white.*

Below the above-mentioned switches are two other rows on a separate panel; more often the upper two rows of these sets are included in the larger panel. The upper two rows connect the negative lead of each machine to the single common negative bus bar on the panel and form the negative connections for both power and lighting; the switches connect through the switchboard to an extra heavy bus bar that runs outside of the other bus bars on the back of the board and must be separated from them at least 1¼ inches for 125 volts. The switch handles for the *common negative are painted blue.*

The bottom row of four switches connect the four equalizer leads of the four dynamos to a common equalizer bus bar when paralleling. These switch handles are usually black, but being smaller, the switch being designed for but 750 amperes, are not readily confused with those for the common negative.

The panel shown on the right (Fig. 219) contains two sets of single-pole circuit breakers, the outer breakers being connected to the positive power bus bar and the inner to the common negative bus bar; the upper pair of the two sets is for connection to the distribution-room of the other dynamo-room (forward as shown) and the lowest pair to the distribution-room nearest the dynamo-room in which the generator board is installed.

The panel shown on the left accomplishes for lighting what that on the right does for power, the capacity of the circuit breakers being 800 to 1000 amperes and 2000 to 6000 amperes, respectively. This panel also contains a voltmeter which can be connected successively in parallel, through the switch shown lower down, with each of the other four voltmeters and the latter be thus calibrated and checked.

Below the power and lighting panels are installed Bristol Recording Ammeters, of 5000-ampere and 800-ampere capacity; they serve to record those variations of load during 24 hours, which ordinary readings at the end of each hour as recorded by log rarely show, and which are useful in tracing heavy loads or overloads as causes of faults or repair.

The Distribution Board.—A design of distribution board common to battleships is shown in Fig. 221. A diagram of the

connections is shown in Fig. 222 and in which the arrangement is reversed from left to right as compared with Fig. 221.

There are three panels on which are mounted the connections to the various circuits to which the energy from the dynamo-room bus bars is to be distributed; these three panels are designated: lighting panel, left; power panel, center; and turret panel, right.

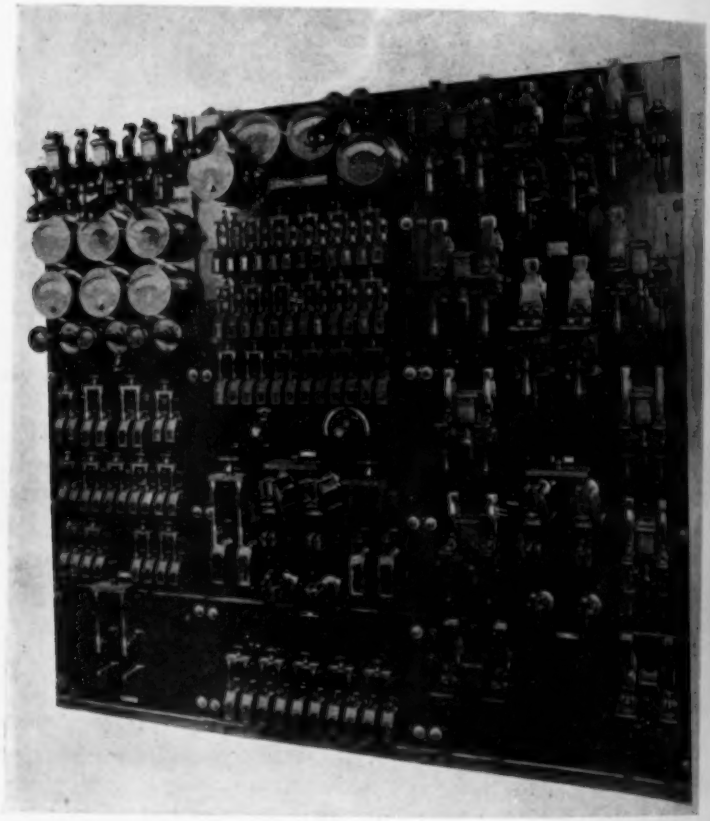


FIG. 221.—Distribution-board (Connecticut).

The lighting panel contains, from top to bottom:

1. Three circuit breakers of 100-ampere capacity, the left and right of which are in the positive lead to each of two 30-inch search-lights; the center breaker is of 200-ampere capacity and is in the positive lead of each of two 60-inch search-lights.

2. A set of six instruments; the upper left hand is the voltmeter for the search-light circuits, the separate circuits for the three search-light lines being connected at will to this voltmeter by the voltmeter switch near the hand wheels (below); the upper center instrument is an 800-ampere ammeter which shows the total load in amperes which is in use on the lighting circuits; the upper right hand instrument is a voltmeter which shows the actual

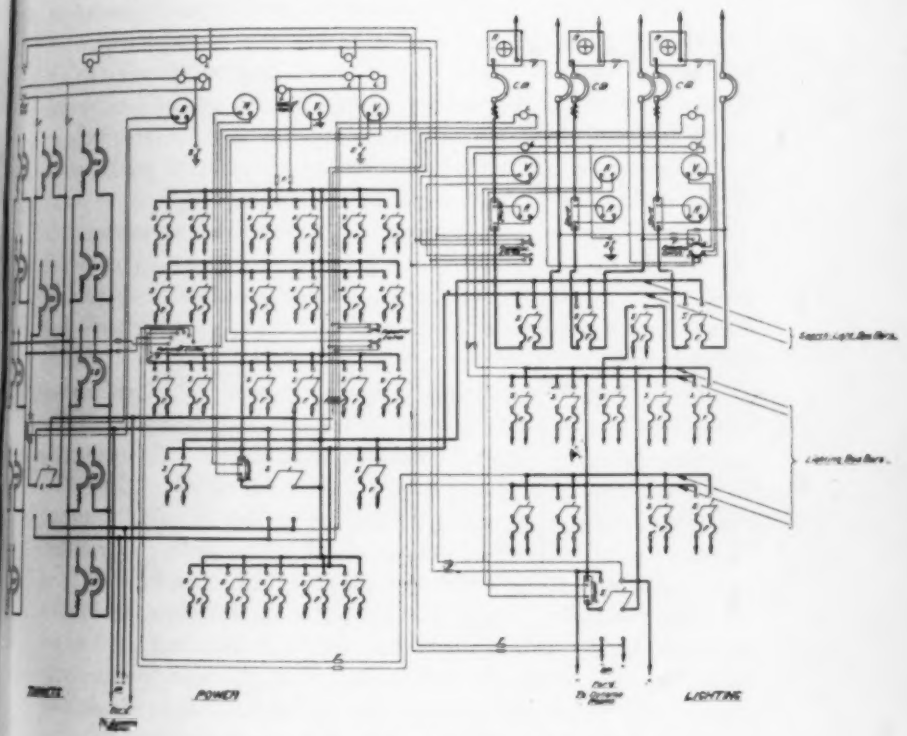


FIG. 222.—Connections of distribution-board (Connecticut).

voltage across the bus bars of the lighting panel; the three lower instruments are ammeters; the left and right are 100-ampere and indicate the current for the 30-inch search-light circuits, the center instrument is 300-ampere and indicates the current for the 60-inch search-light circuit, a switch near the hand wheels indicates whether for the forward or after 60-inch projector.

3. Three hand wheels (the adjacent switches have been mentioned) which control the adjustable search-light resistances on

the three circuits, the rheostats being located near the distribution board and connection made to the hand wheel shafts as in the case of the shunt rheostats of the dynamo-room board; the dead resistance of the search-lights is located elsewhere at any desirable location; ordinarily, but not conveniently, this is the dynamo-room.

4. Three rows of double-pole switches; the upper left and right being for the connection to the positive and negative search-light bus bars for the 30-inch search-light branches and the middle two for the 60-inch projector circuits. The two lower rows are the positive and negative connections to two sets of positive and negative bus bars for the feeders of the distribution panels or large lighting circuits of the vessel or distribution panels in the ship. These are generally of 100-ampere capacity.

5. The large double-pole, double-throw switch to form the connection of the whole panel, except for search-lights, to the positive bus bar on the lighting lead from each of the two dynamo-rooms and the negative bus bar fed from the common negative of each dynamo-room.

The center or power panel contains from top to bottom:

1. Four instruments. The right-hand instrument is a 130-0-130 scale Weston Ground Detector with a switch for connecting in the positive or negative leg of the circuit to be tested, and the various circuits of all three panels can be connected to it through switches provided on the power panel. The right center instrument is a 2000-ampere Weston ammeter for the total current on all turret circuits. The left center is a 2000-ampere Weston ammeter for the total current of all power circuits other than for turrets. The left-hand instrument is a 150-volt Weston voltmeter across the bus bars of the power and turret circuit connections.

2. Three lines of double-pole, single-throw, 100-ampere switches for the various power circuits of the vessel.

3. Two 500-ampere, double-pole, single-throw switches for feeding boat-crane and air-compressor motors. A double-pole, throw-over laminated transfer switch for connections to bus bars for search-lights; these circuits derive their energy from the power panel and not from the lighting panel.

4. A row of five 200-ampere, double-pole, single-throw switches for miscellaneous power circuits.

The turret panel consists of a set of double-pole circuit breakers on the various divisions of energy for power use within the turrets only. There is also mounted on this panel a 2000-ampere, double-pole, throw-over laminated transfer switch which controls the whole load of the panel. The outside studs of this switch connect to two sets of bus bars that are led in connection with those on the power panel, one set being fed from the forward dynamo-room and the other from the after dynamo-room.

The following is a list of the circuit breakers and their uses:

Two type C, form P, 800-ampere circuit breakers for 12-inch turret ordnance power; two type C, form P, 300-ampere circuit breakers for 12-inch turret-turning motor-generator sets; four type C, form P, 300-ampere circuit breakers for 8-inch ordnance power; four type C, form P, 200-ampere circuit breakers for 8-inch turret-turning motor-generator.

The panels of the dynamo-room and distribution boards are mounted by bolting them against angle-iron framing and are set with the lower edge about 12 inches above the deck if at all practicable. The front of the panels are illuminated by shaded lamps placed at the top, usually two in the center panel and one in each side panel; the connections on the back of the board are illuminated by a lamp in the center of the top of each panel.

In making terminal connection to the board for the ends of the feeders, the ends are soldered into connectors similar to that shown at *A* (Fig. 90). Some connections between boards require two or more wires in order that the largest number of circular mils in one wire will not be greater than 1,000,000 circular mils; in that case a grouping of two or more connectors into one are required; *e. g.*, the connections from the dynamo-room switchboard forward to the distribution board aft in a large battleship requires four one-million circular-mil wires for each leg, positive and negative.

All appliances on the switchboard are marked with name plates; each voltmeter and ammeter has stamped on it the number of the generator with which it is in circuit or a name plate corresponding to its search-light or motor circuit.

Distribution Panels.—In order to minimize the number of switches on a distribution board, to decrease the number of wiring appliances in the circuit and to afford a convenient means of controlling lighting mains or mains from which are branched

several small motors, it is customary to install distribution panels at convenient places in the ship. They are slate panels provided with knife switches only, the panel being protected by a perforated ventilating cover that can be locked.

Circuit Breakers.—In general, circuit breakers are used in place of fuses on all circuits of large current capacity which are subject to overload. In effect they are an automatic, circuit-opening switch, with an adjustable range of operation. Their chief point of advantage, perhaps, in addition to preventing excess of current, is in enabling the circuit to be closed with but a small loss of time as compared with that required to replace a fuse; this is of especial value in circuits for motors, such as for turret-turning, ammunition hoists, gun-elevating, and ramming.

The general features of construction comprise:

1. The main switch contacts.

2. A set of auxiliary contacts which make and break the circuit before and after, respectively, the closing and breaking of the main contacts.

3. A locking device holding the main and auxiliary contacts in closed position.

4. A tripping device, usually actuated by a solenoid, to open the locking device.

5. An adjustment for the position of the iron armature in relation to the solenoid.

6. A scale to indicate the range of adjustment that may be obtained.

7. A spring device to rapidly open the main and auxiliary contacts when the locking device is released.

General Electric Company's Types.—This company manufactures different forms of magnetic blow-out (type M) automatic circuit breakers for different classes of service, mainly single-pole. These different forms have some radically different features to adapt them to the special classes of service for which they are designed. All may, however, be used on switchboards or on any direct-current circuit, and with reasonable care and attention will operate under the most severe conditions. The feature of the magnetic blow-out is in the setting up of magnetic lines at right angles to the arc, which increases the actual length of the arc by deflection until it is ruptured by the failure of the voltage to maintain it. The tripping point is adjustable to any desired

current, from 50 per cent below to 50 per cent above rated full-load capacity, by adjusting the calibrating spring of the tripping armature. Destructive arcing is prevented by the use of supplementary contacts placed in a strong magnetic field and arranged to break the circuit a moment after the main contact. The transfer of the arc from the main to the supplementary contacts, and the immediate extinguishing action of the magnet, has made possible the construction of effective circuit breakers for 10,000 amperes capacity. The main contact, which is built up of leaf springs, bears upon the main contact blocks when the circuit breaker is closed. The coil of the blow-out magnet and the

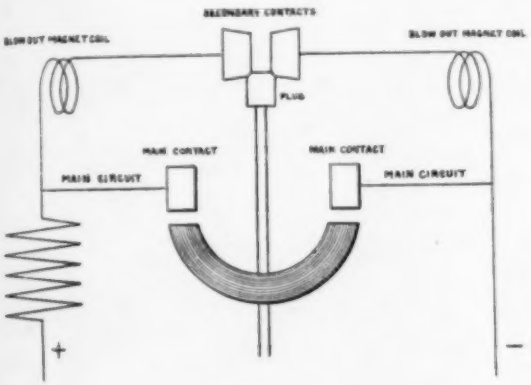


FIG. 223.—Elementary diagram of General Electric Company's type M circuit breaker.

secondary or plug contacts are in multiple with the main contact. Owing to the comparatively high resistance of the secondary contacts practically no current passes through them until the main contacts open; then the whole current passes through the magnet coils and the strong magnetic field extinguishes the arc as soon as it is formed on the plug contact. The plug is not withdrawn until after the leaf contacts have left the contact blocks.

The general diagram of connections of type M circuit breakers is shown in Fig. 223.

The strongest and most rugged of the type M breakers is the form K-3 (Fig. 224), which differs from the form K in the main brush, the manner of tripping, the arrangement of the

secondary contacts, and in the dash pot. The tripping coil, with the connecting studs and nuts, used on the type M, form K breaker is not used on the type M, form K-3 circuit breaker. The necessary power for tripping the latter is obtained from a magnet which is made in the form of a strap encircling one of the main studs at the rear of the panel. Studs are carried through the panel to support the armature and form the necessary magnetic circuit; the armature spring and scale plate are, therefore, on the front of the panel and in an accessible position. The general

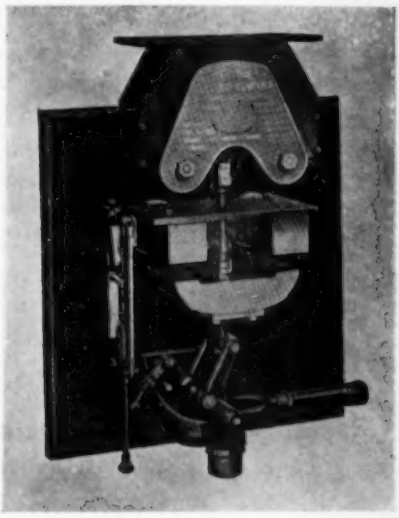


FIG. 224.—Type M, form K-3 circuit breaker, General Electric Company.

method of operation is shown in Fig. 223. The secondary contacts are held in place by a hinged clamp, and are so arranged as to be easily removed upon taking off the pole piece and can be quickly examined or repaired. The dash pot has an air cushion which permits the use of a strong spring to increase the speed of opening of the main brush and to lessen the shock. All sizes of type M, form K circuit breakers are designed for back connections; up to and including 800 to 1200 amperes capacity they can also be furnished for front connection. When the circuit breaker is open, it can be locked open by removing a handle; as the circuit breaker cannot be closed without the handle, removal

of the handle prevents accident or unauthorized closing of the circuit.

The **type M, form L** (Fig. 225) circuit breaker is for use on small power plants where the conditions are not severe, and where a breaker cheaper than the form K, type M is desired; in large plants where severe conditions have to be met its use is not recommended, and the type M, form K breaker should be used in preference. The principle of operation of the form L is the same as that of the form K, but the moving parts are somewhat lighter and differ slightly in general form. The form L circuit breaker

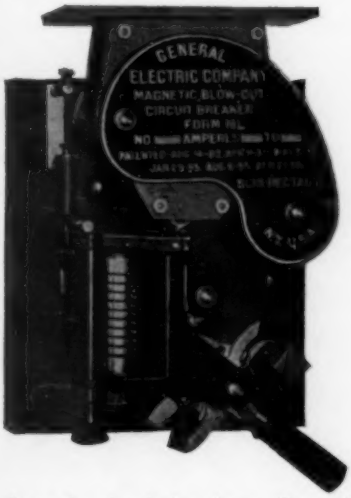


FIG. 225.—Type M, form L, circuit breaker. General Electric Company.

is made in two capacities: 100 to 500 amperes, for front and back connection, and 200 to 800 amperes for back connection only.

As in the case of the form K, the main contacts of the form L circuit breakers are laminated and connected in multiple with the secondary plug contact, upon which the arc is broken. The automatic locking handle is supplied on this circuit breaker.

The **type M, form Q** circuit breakers (Fig. 226), which are made for capacities up to 175 amperes only, are especially designed for protecting power circuits and stationary motors. In general appearance, it is somewhat similar to the form L, but it has no secondary contact, though it has arcing tips to protect the main contacts. The current is broken in a segmental contact

similar to the contacts used in railway controllers. This form of contact has been found sufficient for the maximum capacity of this circuit breaker. There is but one coil for both the tripping magnet and the magnetic blow-out. The magnetic circuit is so arranged that the arc is ruptured in the field.

The automatic circuit breakers, **type C, form D** (Fig. 221, top of switchboard) are furnished in both the single and double-pole constructions; the single-pole is used in the generator circuit of some of the switchboards and the double-pole in motor and search-light circuits. The auxiliary contacts consist of carbon blocks fixed solidly to the main contacts. The moving auxiliary

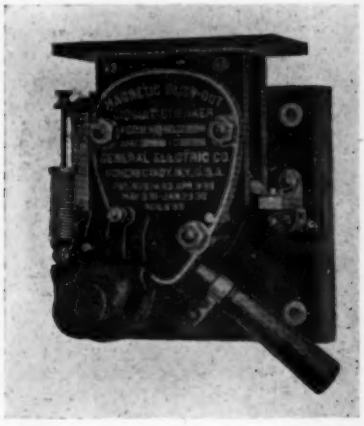


FIG. 226.—Type M, form Q, circuit breaker. General Electric Company.

contacts consist, on either pole, of two curved strips with reinforced ends which make contact in each side of the carbon blocks. The tripping device has an external armature, held away from the core by the spring in tension which is located in the vertical line of the apparatus; an adjusting screw varies the tension of this spring over the range of a scale mounted back of it, thus giving various settings for the current at which the circuit will be opened.

Ward-Leonard Types.—The circuit breaker shown in Fig. 227 is designated as the DH type, double pole, quadruple-break, back-connection.

The details of the construction are as follows:

The main switch contacts on either pole consist of two composition castings, the rear part extending, in a threaded nut, through the slate, and beyond, for the attachment of the nuts which secure to the cable terminal.

The front extension is in rectangular form and milled with grooves, the number depending on the amount of the contact area required. Connection between these front extensions is made by flat copper strips on edge in pairs, each pair being sprung apart by a slitted brass spring which insures that the entire side of each of the copper strips makes good contact; these strips are assembled together in a casting which, with the handle, constitutes the switch lever for one side of the circuit.

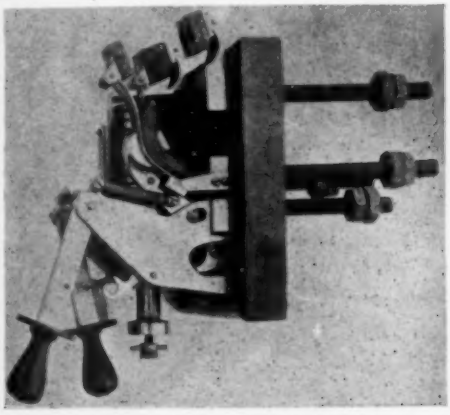


FIG. 227.—Ward Leonard DH circuit breaker.

The auxiliary contacts consist of carbon blocks attached by flat springs to the main contacts. These are connected together, when the switch is closed, by a long carbon block mounted on the side of the casting which holds the flat copper strips.

The locking device consists of a hooked catch pivoted between lugs on the lower side of the main contact. A coiled steel spring tends to keep the catch normally in the closed position; extending from the inner side of the catches are fingers which disengage the catch when operated on by the tripping device.

The tripping device consists of an armature core in an iron-clad frame surrounding a solenoid which is in one side of the circuit.

The operating device is a coiled steel spring mounted in a cylindrical chamber on an extension below the lugs between which the switch lever is pivoted. A shouldered steel stud is pressed upwardly against a boss on the switch lever and tends to hold the switch open; a similar one works directly against the copper strips between the main contacts.

The special feature of this circuit breaker is that it opens both poles of the circuit and it is not necessary to have a special switch in series with it, a feature which is of advantage in the limita-

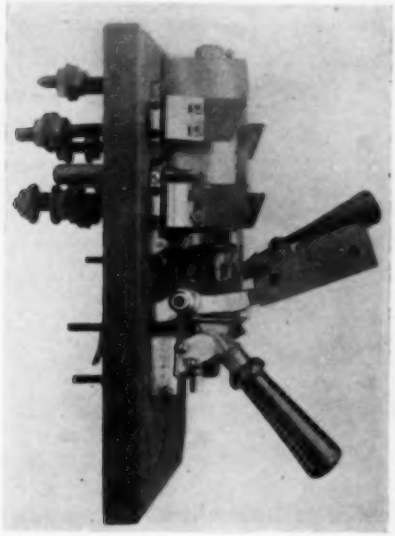


FIG. 228.—Cutter (I. T. E.) circuit breaker.

tions of space on Naval switchboards. By closing first the lever on one side of the circuit and then the lever on the other side, if an excess of current flows, the tripping device will be actuated and the lever which was first closed will fly open.

Cutter Company's Types.—The Cutter circuit breakers are designated as the "Dublarm" laminated-type, I. T. E. (inverse time element), overload circuit breaker, shown in Fig. 228.

The main details of the construction are as follows:

The main switchboard contacts, in either pole, consist of two rectangular blocks on the face of the board from which, extending

through the slate, are threaded studs with nuts by which the cable terminals are secured.

The surfaces of the contacts are plane; connection is made between them by a number of thin copper strips assembled together and bent in a curve, the ends being bevelled off so that, as they impinge on the main switch contacts, they will spread out and each will make a firm elastic contact of high efficiency. The friction along the surfaces of the block insures brightness of contacts.

The auxiliary contacts are double: the first one is made by a copper finger extending from the side of the lower main switch contacts; and the second by two carbon blocks, one being attached to a saddle above the upper main contact, and the other being attached to a saddle and spring and connected to and moving with the lever to which the bent copper strips are attached. The moving carbon is electrically connected with the lower main contact by an insulated strip, secured on top of the bent copper strips and insulated from them by mica; a block of copper at its lower end makes contact during its arc of travel with the first auxiliary contact already described. In some sizes there is a heavier, bent copper finger overlaying those assembled together for the main contacts which acts as another auxiliary contact.

The locking and tripping devices have the same general features as the Ward-Leonard circuit breaker already described.

The opening device consists of phosphor-bronze springs which tend to close a linked joint of the toggle.

Rheostats.

The term rheostat is applied to any type of resistance that is inserted in an electrical circuit for the purpose of cutting down the voltage, the loss in potential, or drop in volts, being numerically equal to the value of the resistance in ohms multiplied by the current in amperes passing at the instant. If a lever or slider is combined, by which the resistance in circuit can be varied, the rheostat is designated an adjustable rheostat, of which the primary or typical form is a simple helix whose turns are insulated from each other by the insulation of the wire or by being laid in grooves on a cylinder of hard rubber or other insulating material.

Much ingenuity has been used in designing rheostats to accomplish the purpose of good range and variation in resistance, by paralleling or placing in series, or a combination of both, at the same time providing for good radiation of heat to keep the resistance material to its normal resistance value; the potential reduction in a rheostat being dissipated as heat, the energy so dissipated may be considerable as cited in the case of searchlight circuits.

Line Rheostat.—This type is usually a variable resistance, or dead resistance in a line for bringing down the voltage value from that of the line to that required for the particular application. A particular case is the Carpenter rheostat used with the

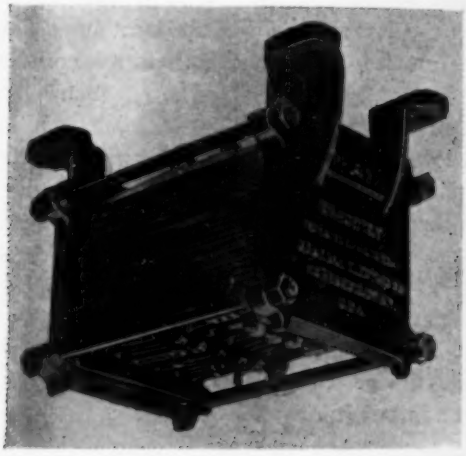


FIG. 229.—Pressed ribbon (PR) rheostat.

photometer; this type has a number of wires embedded in powdered enamel, the enamel being baked to a solid mass; good radiation is effected by casting ribs on the disc.

Shunt Rheostat.—This rheostat is colloquially termed the **box,** to distinguish it from starting boxes. Formerly this type was constructed by winding two sets of wire on slate bases, the lever connecting by brushes on the bared surface of the wire; latterly the various forms are more like starting rheostats and the resistances are made of coiled German silver wire or simply ribbon on insulators.

Starting Rheostat.—This type has been spoken of in connection with motor control. The type is colloquially known as a **starting box.**

Instances of rheostats commonly met with on board ship in connection with power circuits are the following:

The Pressed Ribbon (PR) Rheostat.—The PR type of rheostat is shown in Fig. 229. It consists of two cast-iron end frames held in position by four rods. To each end frame is cemented a fire brick having six slots. These fire bricks support six panels of filling, differing somewhat in the various rheostats, but consisting essentially of malleable-iron top and bottom strips provided with binding posts, between which are stretched back and forth several layers of German silver ribbon, the different layers being insulated from each other by asbestos. In addition to the German silver resistance many panels have iron radiating pieces inserted between the various layers to assist in dissipating the heat. The rheostats are generally so mounted that the panels lie in vertical planes, allowing the air to circulate freely between them and carry off the heat; to prevent the absorption of moisture the panels are dipped in japan.

The binding posts consist of lugs, provided with set screws, cast on the top and bottom plates. A binding post is provided at both ends of each panel for convenience in making connections to the controller. The panels are connected together by short copper strips fastened by screws to the top and bottom plates. The connections are such that the six panels of the rheostat are in series with each other, but in some cases longer strips are used and the panels are connected either two or three in multiple. These rheostats are designated by a serial number; such as 218; if the panels of the rheostat are connected two in multiple the series number is followed by the letter A, as 218-A, and if connected three in multiple it is known as 218-B.

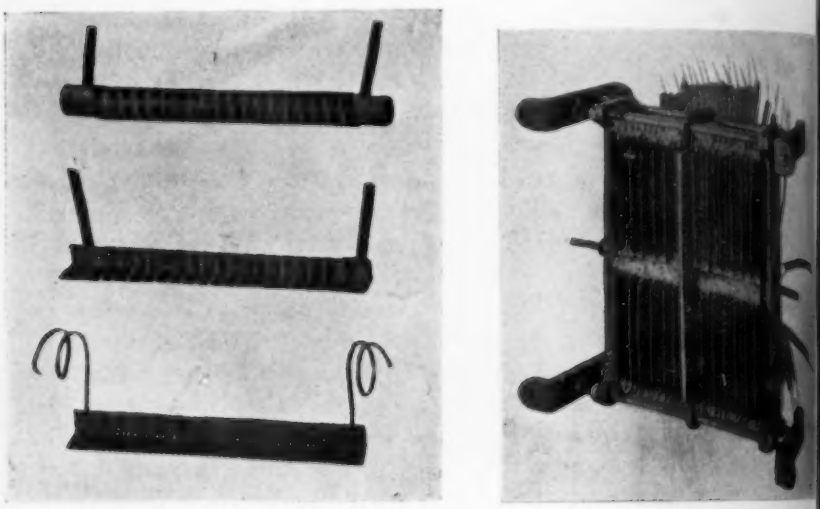
The panels are insulated from the iron frames by the fire bricks; to give more insulation, insulating bushings are provided for the bolt holes in the feet of the rheostat frame so that each rheostat frame is insulated from the ship; should the connections in any way make contact with the rheostat frame the whole system would be grounded.

The panels have terminals at each end for connection of circuits and also flat plates which connect the panels together. The

points at which each circuit should be attached to the panel are determined by trial and are shown in the diagram of the rheostat connection furnished with the controller. The number designating the filling of the rheostat is stamped on the end of the frame; if it is necessary to install a spare one an exact duplicate should be employed.

The Packed Card Rheostat.—This type of rheostat is for circuits of moderate capacity and is so proportioned as to give a uniform variation in resistance. The type derives its name from the method of construction.

A tube of asbestos (Fig. 230) on a steel mandrel, is wound with German silver wire or ribbon; it is taken from the mandrel



Wound tube and pressed cards. Showing iron plates between cards

FIG. 230.—Packed card (PC) rheostat.

and pressed in the V-shape section shown; this construction constitutes the card and is the unit resistance used in making up the rheostat. The cards are assembled side by side with asbestos between successive cards, the number of cards determining the amount of resistance. To increase the radiation surface, iron plates, somewhat wider than the cards, are inserted at intervals between the cards and project beyond the resistance section; the

cards and iron plates are then clamped by end plates and bolts. The use of cards enables a large amount of resistance to be placed in a comparatively small space, while the shape into which they are bent insures their maintaining a fixed position.

Voltmeters and Ammeters.

The Weston types are preferred and constitute the general supply.

The general principle is derived from that of the D'Arsonval galvanometer. A coil of wire (Fig. 231) is wound on a rectangular bobbin of thin sheet copper or aluminum and mounted in delicate jewel bearings, on brass mountings secured to the poles of a permanent steel magnet, to whose poles are secured pole

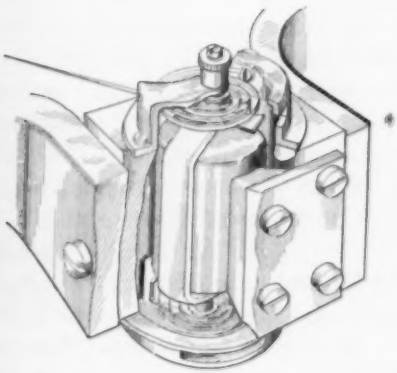


FIG. 231.—Coil and poles of Weston instruments.

pieces of soft iron which carry the magnetic lines to more closely embrace the coil. Within the coil is a hollow soft iron cylinder, whose office is to concentrate the magnetic field through the coil. Motion of the coil is controlled by a coiled spring at the top and bottom; when a current passes through the coil the bobbin swings to bring the lines of force due to the current parallel with those of the permanent magnet; this motion is resisted by the spring, hence the spring is the controlling force, and the instrument is independent of the earth's force. The bobbin also exerts a restraining force, due to the induction of an inverse current in the closed circuit of the bobbin metal while the coil is moving; this

induction has the important effect of damping the oscillations of the needle and rendering the instrument very dead-beat.

The needle is of aluminum, the vane set vertically to give as narrow and fine an indication as possible, and a mirror arc is placed below the needle to eliminate errors of parallax. The coil terminals connect to the spring, the other end of the spring being connected to the instrument resistance. As the angle of deflection is nearly proportional to the current strength the divisions of the scale are uniform. It is evident that for a deflection of a given number of scale divisions, for scales of the same maximum, the current strength in the coil will depend upon the potential at the coil terminals and will be the same whether the instrument be a voltmeter or an ammeter; it only requires about 0.015 ampere for the full deflection to the scale maximum.

The essential difference in construction between the voltmeter and ammeter is the method of impressing the appropriate potential at the coil terminals for the difference in method of instrument use.

For the voltmeter, which is to be connected directly from the positive to the negative side of a line and thereby derive the full potential of that line, it is necessary that a sufficient resistance be inserted in series with the windings of the movable coil that the full potential of the line may be reduced to that voltage which will cause the coil to swing the needle to the appropriate scale division; the amount of resistance in the coil spring, and instrument resistance taken in series, differs with the full scale maximum, but approximates 100 ohms per scale division; this gives about 15,000 ohms as the resistance of a 0 to 150-scale voltmeter and a full deflection total current in the coil of approximately 0.0053 ampere for 80 volts, 0.0073 ampere for 110 volts, and 0.0083 ampere for 125 volts; the energy absorbed is therefore negligible.

For the ammeter, which is to be connected by a shunt across a resistance in series with one leg of the line, the potential at the coil terminals is readily obtained by connecting a "shunt" in the line whose resistance will be that which will ensure the appropriate potential for the coil; that is, since the potential between any two points of a wire (drop) is equal to the resistance between those two points multiplied by the current in circuit, or $C \times R$, it is only necessary to so proportion the resistance between the points of connection of the coil terminals as to obtain the appropriate

potential for the coil. The resistance is small and represents a negligible amount of absorbed energy. For switchboards the ammeter shunt is made up as a block of copper and resistance strips, the ammeter being connected by flexible leads to contacts on the shunt, which contacts must be on the blocks to obviate errors due to joints; this method obviates running extra bus bars or cables to the instrument. Each ammeter, its flexible leads, and its shunt are given the same number that all may be used together; the leads and shunt will differ for each instrument and must be used with that instrument only; the leads are included in the resistance of the instrument circuit and, obviously, must not be altered. A number of shunts are sometimes used for test instruments; one shunt has a resistance which gives the readings of the scale as marked; a second has but one-tenth of this resistance and produces but one-tenth of the potential (and deflection) of the first, hence the readings for this shunt are to be multiplied by 10; a third has but one one-hundredth the resistance of the first and the readings for this shunt are to be multiplied by one hundred, and so on; hence the original scale of the ammeter can be made available, by changing the shunt, to record 10, 100, and so on, times the scale reading. More frequently the instrument scale is marked to give a direct indication of the actual reading due to the shunt employed. Without its shunt the ammeter is a sensitive millivoltmeter.

The resistance material for voltmeter resistance and the ammeter shunt is an especially prepared alloy having a zero temperature coefficient; but the condition is, for the portable type (having a copper shunt within the instrument), more exact for a temperature assumed by the resistance material at the expiration of two minutes than before or after.

The circular type of voltmeter and ammeter is shown mounted on the switchboard of Fig. 219. It is a practically water-tight type, having an inner chamber in which the connections are made, and into which the leads are run water-tight; the case cover is secured against an annular packing.

The portable voltmeter is similar in appearance to the portable ammeter of Fig. 232. It is a double-scale instrument, reading 0 to 150 volts or 0 to 15 volts, accordingly as the connections are made to a binding post marked *A* or a binding post marked *B*, the difference in reading being effected through a section of the

same series resistance, 1500 ohms in the first case, and 15,000 ohms in the second. A key is inserted to make and break the circuit as desired, and may be held down or released by turning the hard rubber cap.

The portable ammeter is shown in Fig. 232. The portable ammeter has its shunt block enclosed in the case.

Weston instruments are designed to be used either vertically, or horizontally, or at an angle, but accuracy requires that they should be calibrated for the particular position of general use.

FIG. 232.—Weston portable ammeter.

Although the casing is intended as a magnetic shield, the instruments should be removed as far as practicable from the influence of extraneous magnetic influences. Similarly an instrument should not be used in close proximity to iron, such as a deck or bulkhead, and thus decrease the flux through the air gap; this will cause the instrument to read importantly lower than the actual.

In using a double-scale voltmeter, the higher scale of the instrument should be first used unless it is certain that the voltage is within the range of the lower scale; the resistance wire may be as low as 0.001 inch in diameter and would burn out at 150 volts; to prevent a burning out of ammeters it is the rule to install one of higher capacity than the maximum intended load.

Weston Ground Detector.—This instrument, shown on the switchboard of Fig. 221, differs from the voltmeter in the method of placing the coil and in having its zero in the center of the scale, reading up to standard voltage on two scales, one on each side of a central zero. As explained below, the pivot of the lever switch is connected to one terminal of the fixed resistance and moving coil; the other terminal is connected to ground.

Referring to the diagram (Fig. 233). If the lever 1 is connected to 4 and the positive leg of the circuit, and there is a ground on the positive leg, no current will pass through the instrument resistance (and coil) to ground, as the ground 2 is parallel with 4 and the potentials at the instrument terminals due to the two sources are practically equal and opposite. But if the

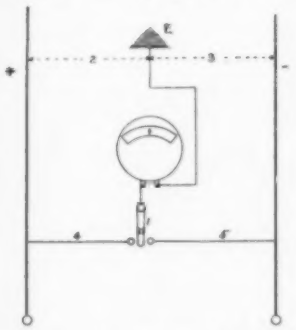


FIG. 233.—Diagram illustrating action of Weston ground detector.

negative leg is grounded, 3, a current will pass from 4, by 1, through the resistance (and coil) of the instrument by E and 3 to the negative leg, and the pointer of the instrument will deflect to the left hand as looked at. It will be noted that the resistance of the instrument and the insulation resistance of the negative leg are in series with each other. The conditions for the connection of 1 on 5 will be similar to those of 1 on 4, but the current will pass oppositely through the instrument via the ground at 2 and the pointer will deflect to the right-hand side of the scale.

The deflection in each case is used to determine the approximate insulation resistance in ohms of the connected circuit in the following method of calculation. The fundamental proportions depend upon the principle that the drop in potential in any two portions of a series circuit are proportional to their resistances; *e. g.*, if R and R' denote two resistances in series and C the cur-

rent flowing through both, then $CR = E$ = drop in R, and $CR' = E'$ = drop in R', from which $R : R' :: E : E'$.

Let A = Voltage of a circuit to be tested (line voltage).
B = Resistance of the ground detector employed.
C = Deflection obtained when the positive leg is grounded.
D = Deflection obtained when the negative leg is grounded.
X = Resistance in ohms of negative leg side to ground.
Y = Resistance in ohms of positive leg side to ground.

The fundamental consideration is that both the positive and negative legs (2 and 3, Fig. 233) are grounded, and that 1 is connected to 5. The conditions are: first, a current can pass through the instrument resistance and ground 2 to the positive leg and, these resistances being in series, there will be a deflection on the right-hand side of the scale of C volts; second, the ground 3 is in parallel with 5, and its terminus at E has also a potential in parallel with 5, and somewhat affecting the potential C. The drop through Y ohms will evidently be equal to $A - C$, hence

$$C : A - C :: \frac{1}{\frac{1}{X} + \frac{1}{B}} : Y \tag{1}$$

For the contact of 1 on 4:

$$D : A - D :: \frac{1}{\frac{1}{Y} + \frac{1}{B}} : X \tag{2}$$

Combining:

$$X = B\,\frac{A - C - D}{D} \tag{3}$$

$$Y = B\,\frac{A - C - D}{C} \tag{4}$$

If the circuit is grounded on the negative leg only, C will be zero and

$$X = B\,\frac{A - D}{D} \tag{5}$$

If the circuit is grounded on the positive leg only, D will be zero and

$$Y = B\,\frac{A - C}{C} \tag{6}$$

B is marked on the instrument as on other voltmeters. A graphic chart is usually supplied to ships from which *X* and *Y* can be picked off.

When testing insulation resistance with this instrument, a closer approximation is obtained by having but one generator on the bus bar and testing out one circuit at a time.

Caution: 1. It is better not to use the instrument until the circuit under test has been first tested by the lamp detector. 2. Be careful not to touch the live parts of the instrument, or leads, with the hand or fingers this would shunt the insulation resistance under test through a comparatively small resistance, and the resulting deflection would be for the two resistances in parallel, not for the insulation resistance alone.

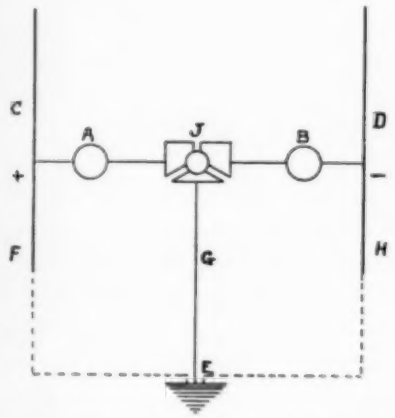


FIG. 234.—Diagram illustrating action of lamp ground detector.

In the portable type of instrument a binding post is supplied at the top for the ground wire. At the bottom, on each side, is a binding post for the connecting wires and also a push key which connects its terminal to a switch bar (inside), to which bar the instrument resistance (and coil) are connected; the negative leg of the circuit is connected to the left hand (marked —) lower binding post. To test for a ground on the negative leg, the push key on the side marked + is pressed; for a ground on the positive leg, the key marked —. The same formulæ apply to this instrument. The push keys and contacts are covered with hard rubber, preventing any shunting effect in handling. In late types

but one push key can be operated at the same time, thus obviating any chance of short-circuit.

Lamp Ground Detector.—The office of this instrument is mainly to indicate that a ground exists on a circuit, and it will only so indicate when the insulation resistance of the circuit is very low.

The lamp detector consists of two 16 c. p. incandescent lamps installed in series between the positive and the negative bus bars of the switchboard, the series connection being made through a plug switch, the plug also switching in the ground connection.

In the diagram (Fig. 234), *A* and *B* are the two 16 c. p. lamps, *A* connecting to the positive bus bar, *C*, and *B* connecting to the negative bus bar *D*. *J* is the plug switch with connections to *A* and *B*, and also, by *G*, to earth (a wire attached to a convenient metal part of the ship which is the metallic connection with the outside water).

If the plug is inserted at *J*, three cases arise:

I. Both *C* and *D* are free from grounds.

In this case there will be no connection of *C* or *D* with earth, and the current will flow from *C*, through *A*, *J*, and *B*, to *D*. *A* and *B* being in series, the sum of their resistances is added to that of the lead wires and this doubled resistance, at the normal potential between *C* and *D* causes them both to burn a dull red; that is the double resistance causes the potential at the lamp terminals to be but half of that required when either *A* or *B* is to burn brightly.

II. There is a ground on *C*.

In this case *C* is in communication with earth, the current flowing by *F* to *E*, by *G* to *J*, and thence by *B* to *D*. Hence, if there be a dead ground on *C*, *A* will be short-circuited through *F*, *E*, and *G*, and will be extinguished, while *B*, being no longer in series with *A*, will receive the full potential of the line and will burn brightly; if the ground on *C* be not a dead ground, *B* will be of a brighter tinge than *A*, the current dividing between earth and *A* in inverse proportion of their resistances.

III. There is a ground on *D*.

In this case *B* will be extinguished or dimmed, the current passing from *C*, through *A*, *J*, *G*, *E*, and *H* to *D*, or dividing at *J* through *G* and *B*.

From cases II and III it will be seen that that lamp is the dimmer which is directly connected with the grounded circuit.

The lamp detector is not a delicate test for grounds, it merely gives warning of any approach to low insulation resistance in the

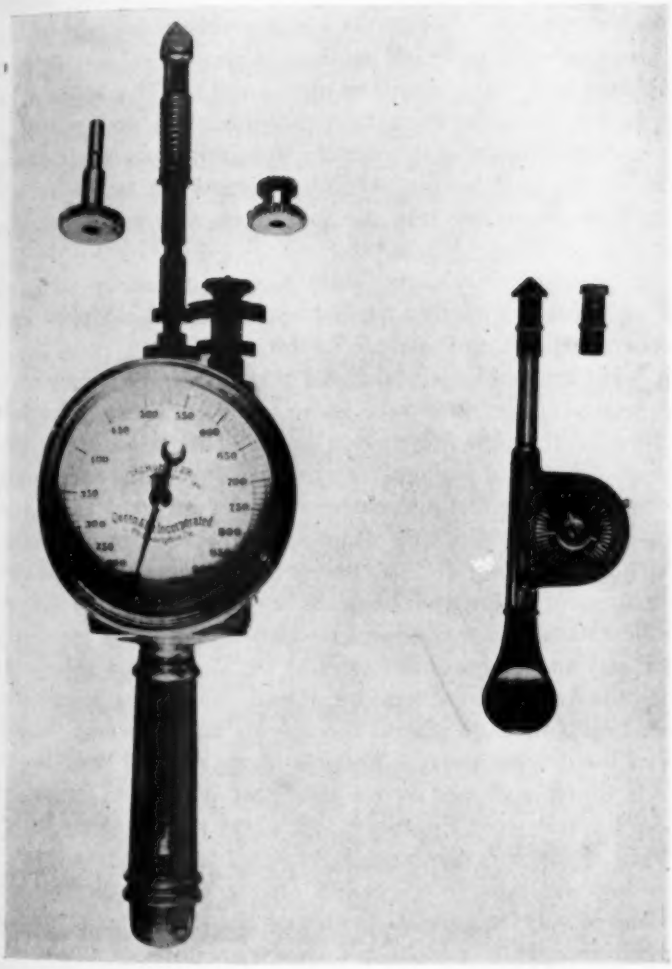


FIG. 235.—Hand tachometer and hand speed counter.

circuit. The circuit on which the ground exists is discovered by elimination, opening one circuit switch after the other until both lamps, *A* and *B*, glow alike.

Tachometer (Fig. 235, left).

This instrument is a direct-reading speed register; its construction is based upon centrifugal force and consists essentially of a pendulum ring pivoted on a central shaft. The ring is normally held at an angle to the shaft, when at rest, by two carefully calibrated springs. When the shaft revolves the ring tends to assume a position in which its plane is perpendicular to the shaft, which tendency is resisted by the springs. The action of the ring is transmitted to the pointer through a link work motion, the pointer indicating the number of revolutions on the calibrated scale of the dial; having carefully aligned the tachometer with the mechanism under test, the instrument will prove quite dead beat.

For readings within the scale range (ordinarily 1000), the driving point is directly attached to the central shaft; its sleeve is split and holds to the shaft by friction.

A wide range of usefulness for the instrument is provided by two sets of gears, the revolutions of the driving point being transmitted through these gears to the shaft instead of directly; one set drives the tachometer shaft at double the speed of the mechanism under test and ensures greater accuracy in the measurement of low speeds; the other set reduces the revolutions one-half, thus providing for speeds up to twice the scale reading of the instrument. Each set of gears has a specially adapted sleeved spindle (stamped for the speed) which carries a cog wheel on its inner end and is continued beyond the sleeve as a spindle over which the driving point is to be slipped, the driving being accomplished by a through pin on the spindle and scores on the inner end of the driving point. There is also a sleeve having two cog wheels which is slipped over a slide post attached to the case and held by a follower; the inner cog wheel of this sleeve engages that wheel which is permanently attached to the instrument shaft, the other engages the cog wheel on the sleeved spindle. Since the sleeved spindle journals loosely on the shaft, the driving point drives this spindle which in turn drives, through its own cog wheel, the cogs of the sleeve on the side post and that on the shaft.

Hand Speed Counter.

The Starrett type, a common supply, is shown in Fig. 235, right. The spindle carries a worm (inside the casing) which

engages the cogged gearing of a wheel attached to the outer dial. The dial is marked for 100 divisions, reading both to the right and to the left. At each revolution of the outer dial a lug inside engages a pin of the inner dial and moves this dial one indication; the indications are recessed to take a spring pointer, which acts as a detent to the inner dial. The spindle is pointed and bevelled to take on the shaft center of the machine whose speed is to be tested; it is also provided with a sleeve tipped with a rubber cone which can be slipped over the point when the use of the sharpened point is not applicable or desirable.

The handle is of hard rubber and is sometimes made with a spring clutch grip to engage the worm only when the grip is pressed.

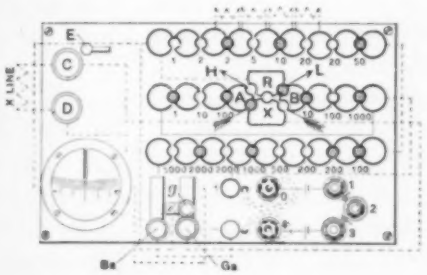


FIG. 236.—Connections of acme testing set.

The hand counter must be timed by a time-piece, and is therefore inconvenient as compared with the direct-reading tachometer; it is valuable as a check on the tachometer readings.

Testing Set (Acme).

The plan of this small box of resistance coils, or bridge, is shown in Fig. 236, and is a somewhat different arrangement from the more common forms of bridge in that the bridge (ratio) arms are in the second row and have a commutating block to transpose the two ratio arms, *A* and *B*, so that they are passed through in the reverse order.

The top row of blocks is connected to the bottom row by a heavy copper bar which joins the right-hand (50 and 100) blocks; these two rows together constitute the known resistance, or rheostat, and cover any resistance from 1 to 11,100 ohms on removing the proper plugs. The lower left-hand block (5000) is

connected to the lower line post *D*. The upper line post *C* is connected to block *X*; this block *X* has no other permanent connection excepting that it is joined to the galvanometer key. The block *R* is connected to the upper left-hand (1) block of the rheostat and has otherwise no connection except by plugs. The end blocks (1 and 1000) of the middle row are connected together by a heavy copper bar; each half of this now constitutes a bridge arm, designated *A* (to the left) and *B* (to the right). Starting from the lower line post *D*, the circuit is continuous from there, through the rheostat, and then through first one bridge ratio arm and then the other, back to the line post *C*.

The function of the commutator is merely to transpose the bridge arms *A* and *B*, so that they are passed in reverse order. All the above connections are in circuit with the resistance to be measured and are therefore made heavy to add no appreciable resistance to the circuit.

The two battery terminals marked + and —, are connected, one directly to the junction common to the two bridge arms, the other through the battery key to the rheostat. The two galvanometer terminals are connected, one directly to the block *R* or, what is equivalent, to the upper left-hand (1) rheostat block, while the other connects through the galvanometer key to the block *X*. The blocks *A*, *B*, *R*, and *X* can be connected by plugs. The connections described from the three arms of a Wheatstone bridge, the fourth arm being the resistance to be measured which is to be connected to the line posts *C* and *D*.

When the commutator plugs are inserted as shown in Fig. 236, $A:B::X:R$, but if placed in the other diagonal $A:B::R:X$.

There are four dry-cell batteries, and 1, 2, 3, or 4 cells can be used by placing the caps of the flexible lead of the negative connection on the cell of number corresponding to the number of cells required.

To measure a resistance. Connect the terminals of the resistance to be measured to the line posts *C* and *D*, and place the negative battery connectors on battery 1, this throws one cell of the battery into circuit which is sufficient until balance is roughly attained. Unplug the 100-ohm coil in each bridge arm, and place the commutator plugs as desired for ratios as per table below. Remove plugs from the rheostat until the aggregate resistance unplugged is, as nearly as may be guessed, equal in value to that

of the unknown resistance. Then press the *battery key*, and, *holding that down*, momentarily press the galvanometer key. If the galvanometer needle swings toward +, the resistance unplugged in the rheostat is too high and should be reduced. If the deflection is toward —, the resistance is too low and should be increased. By altering the resistance in this way a value will soon be found wherein a slight change either way will reverse the deflection of the galvanometer needle. The rest of the battery may now be put in circuit by placing the negative battery connector on 4. If the keys be again pressed, *first the battery key, then the galvanometer key*, a greater deflection will be obtained than before for the same variation in the rheostat, and, therefore, the adjustment can be made more accurately. With

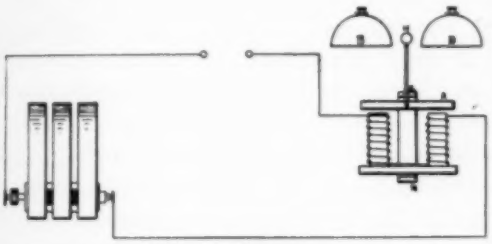


FIG. 237.—Diagram of magneto connections.

bridge arms of equal value this is the best result that can be obtained, but by selecting more suitable values for the two arms a considerably higher degree of accuracy may be secured.

The following table shows the value of A and B, respectively, to be chosen when measuring any resistance within the range of the set:

Below	1.5		ohms, make	$A=$	1, $B=$ 1000
Between	1.5 and 11		" "	$A=$	1, $B=$ 100
"	11 "	78	" "	$A=$	10, $B=$ 100
"	78 "	1100	" "	$A=$	100, $B=$ 1000
"	1100 "	6100	" "	$A=$	100, $B=$ 100
"	6100 "	110,000	" "	$B=$	1000, $A=$ 100
"	110,000 "	1,110,000	" "	$B=$	1000, $A=$ 10
"	1,110,000 "	11,110,000	" "	$B=$	1000, $A=$ 1

Testing Generator, or Magneto.

This instrument is of the alternating current type commonly seen in connection with telephone service.

Its field is made by three horseshoe, permanent magnets having

soft iron pole pieces which closely embrace the long, Siemens type, shuttle-wound armature.

The armature is revolved by a train of wheels actuated by a hand crank.

The armature circuit is wound with No. 36 B. & S. G. wire and has a resistance of 1700 ohms (differing for types of manufacture), corresponding to a length of about 4100 feet for that resistance. The coil ends are attached to two insulated collector rings on which the brushes take. The alternating voltage at the terminals for maximum speed is from 30 to 40 volts.

Within the box case is a "ringer" having a clapper (Fig. 237) which swings between two gongs. The clapper armature vibrates between the two electromagnets shown, which are so mounted on one end of a permanent magnet as to be polarized, that is, when no current is passing, the cores of the electromagnets will be similarly magnetized, and their upper ends, opposite the soft iron armature to which the clapper is attached will be of the same polarity. The soft iron armature, which is mounted on the opposite pole of the permanent magnet, will be usually attracted to one of the electromagnets. The coils of the electromagnets are wound in opposite directions; when a current passes, the magnetism of one electromagnet is strengthened and that of the other weakened; the current being alternating the clapper is swung from one gong to the other for every revolution of the magneto's armature.

The magneto will not ring through a resistance greater than 50,000 ohms, hence it is not available for testing insulation resistances, except that if it will ring it shows that the ohmic insulation resistance is 50,000 ohms or less. Its chief use is for testing the continuity of a circuit.

CHAPTER XII.

GENERAL NOTES ON GENERATING SETS AND MOTORS.

The essence of proper endurance and successful operation of an electrical plant resides in an interested attention on the part of the operating force and a careful inspection of that attention by authority. The elements of attention are:

1. Scrupulous cleanliness.

2. Thorough water-tightness, maintaining the integrity of the water-tighting designs as installed.

A particular case of this is the prevention of access of salt water, that inveterate enemy of electrical appliances on board ship which corrodes connections and forms short circuits and grounds through the resulting copper salts all of which are, more or less, electrical conductors.

3. Sound connections.

The mere oxidation at connections introduces resistances which prevent the proper functioning of appliances, dissipate the electrical energy in heat and cause unauthorized losses. Loose connections are always bad practice and necessarily faulty.

4. Timely repairs of faults.

The "stitch in time" is mandatory in mechanical and electrical faults, tending as they do to become rapidly worse and, generally speaking, a bill of repairs may be taken as the inverse measure of this element of attention.

The Engine and Its Connections.

The type of engine for driving dynamos, etc., at a high rate of rotation is known as a high-speed engine, the separating line from a low-speed engine being generally accepted as at from 200 to 250 revolutions per minute. The type also differs from general engine designs in having a short stroke. The combined features of high speed and short stroke place the type in a class of itself—distinct from the high-speed types for locomotives, torpedo-boats, and the like—and requires distinct elements of design which may

be noted in the peculiar appearance of its normal indicator diagram. The distinct advantages of the type are compactness, lightness, and great strength; as to efficiency and economy, experiments with over 100,000 horsepower indicate that these factors are quite equal to those of other types for similar capacity. The explanation is found in the better lubrication of the working parts, and in the better distribution of stress by reason of the increased inertia due to the high rate of reciprocation of the pistons.

Efficiency and economy are important factors in the final criterion of the performance of an engine and their practicable evidence is the expenditure of coal, developed in the engine as a consumption of steam; as the efficiency is dependent upon this steam consumption, a final criterion of performance (durability apart) may be said to rest on water consumption. Coal endurance is ever a serious question in a man-of-war, and excessive water consumption in auxiliary engines results in a cumulative demand on the coal supply.

The necessary waste steam consumption in an engine is usually distributed amongst four well-established sources of loss: Clearance; port friction; condensation, and leakage.

Clearance must be provided for easing the racking strain of fast piston reversals, and must necessarily increase in percentage as the number of reversals is increased. The volume of clearance in any given pattern of engine varies with the area of the piston and is nearly independent of the length of stroke; but when expressed as a percentage of the volume of the cylinder it will increase as the stroke diminishes—the usual 3 per cent on a 5-foot stroke would become 36 per cent if the stroke were reduced to 5 inches. This clearance loss is severe in all high-speed engines and is practically constant for a type.

Port friction may be defined as a sort of added clearance; it is the volume necessary for the ports combined with a choking of the steam in its passage to the cylinder. This loss is nearly a minimum in dynamo engines having piston valves, as the ports are fairly large and straight; in those which have flat valves the ports are curved to an approach to a right angle and port friction is often greater for this type of valve than for piston valves.

Condensation is found in all reciprocating engines, and is principally due to the fact that the wall of the cylinder is alternately exposed to high and low temperatures. The temperature

difference between the low and high temperature approximates 180° C., or the temperature difference between boiling water and ice. In a compound engine the temperature difference is approximately halved in each cylinder, with necessarily great reduction in condensation. It is obvious that the rate of cooling will vary with the time of exposure, that is, it will be less with increased speed, and in general it is established that there will be a saving of nearly one-half by doubling the speed. This is only an approximation, however, as part of the condensation is due to the radiation to the atmosphere, and another part to the direct conduction of heat from the cylinders to the bed-plate and working parts of the engine, a condition noticeable in some enclosed engines. Steam jacketing is naturally suggested as a remedy for condensation, but in small engines, even when compound, the gain in the cylinder is so evenly balanced by the large loss in the jacket as to render the expedient expensive and unnecessary.

Leakage is an inherent vice of piston valves and is much increased by wear, causing back pressure and increased loss from that source; it appears in the cylinders as well, as the pistons wear. Valve leakage will be readily understood when it is stated that from this loss alone it has been found that an engine apparently in good order, even when standing still, took as high as 30 to 40 per cent of its normal requirement of steam; and, though the automatic governor handled it well as a new engine, and when running without load, it ran practically independent of the governor under the new conditions until loaded to about 20 per cent. It is quite practicable to overcome the wear of piston valves by packing rings. Packing a piston valve requires bridges in the ports and that the bridging be diagonal; this involves an expense which would be expensive in casting, but is accomplished by a cast-iron bushing (liner) in the valve chest with appropriately bridged ports. It is not worth while to put packing rings on the small horsepower valves as they can readily be turned from spare rough castings.

From 15 to 25 per cent of the steam delivered at the throttle is the plain statement of the summation of these four losses in a new dynamo engine that has been subjected only to those preliminary trials necessary to put it in proper order for turning over to the ship and the statement is believed to be conservative. The remedy for large water consumption is more closely fitting valves

and, in engines not so fitted, packing rings on the piston and on the L. P. valves if of the piston type. The ship fault of throttling down is to be noted as a means of increasing water consumption. Throttling down is sometimes practiced to reduce pressure when running under light loads, and is done under the impression that it saves steam, and also for the reason that a weight spring governor is inclined to be noisy at small loads if the throttle is wide open; since the fit of piston valves is what is known as an expansion fit, the best results being obtained at the steam temperature of the standard pressure of the design throttling down, reducing pressure, and therefore temperature, will promote leakage. At any load the governor will regulate the expenditure of steam more efficiently than any attendant at the throttle, and it should be the invariable practice to run at the prescribed number of revolutions as shown on the name plate, with the throttle wide open, and let the governor take care of the steam as it was designed to do. The noise of the governor due to carrying too light a load is readily remedied by switching on a ventilating blower, or the lights of a circuit which does not affect the overhead lights of the sleeping quarters of the men, and the extra load will actually cause no additional consumption of steam owing to the reduced leakage in the valve.

In the following remarks on engines, many conditions are those which are met with in engines in general but it will be remembered that wear and tear are much enhanced in short-stroke engines by high speed, and non-oiling cylinders and valve chests; the use of oil in cylinders has passed beyond the pale of recognition as it is certainly demonstrated that the oil considerably shortens the life of the main boilers and condensers, hence the *onus* is thrown upon the engine.

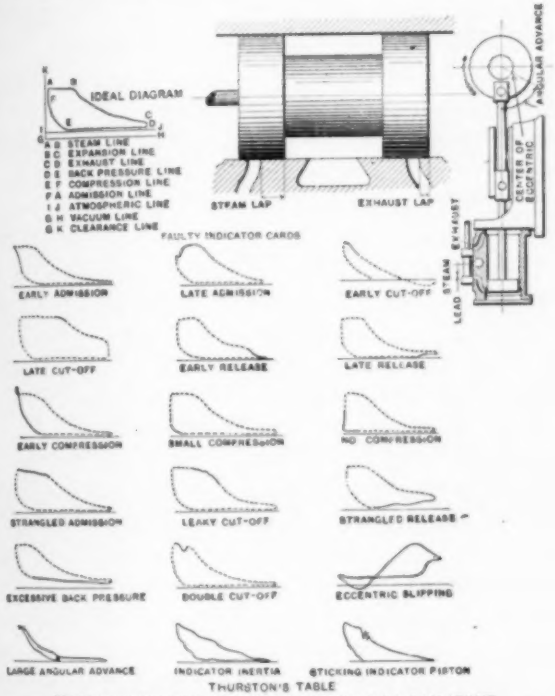
Vibration.—The effect of this fault on working parts and connections can aggravate many others, but the immediate effect is the loosening of joints in the piping. If vibration can be detected to a sensible degree when standing at any point near the periphery of the foundation the fault is important enough for correction. The method of repair must be determined for the particular case and the construction of the compartment and the deck underlying the dynamo-room.

Noise.—All noise should be eliminated. Apart from noise due to lost motion and wear, the following may occur:

Chattering of Check Valve in the Drain Piping.—The valve should be taken out and the seat fitted with asbestos washers.

Chattering of the Reducing Valve.—This will often occur if the valve is installed on a vertical pipe instead of on a horizontal.

Chattering of the Exhaust Check Valve.—The valve is not an indispensable attachment; the fault can best be relieved by the removal of the valve.



THURSTON'S TABLE

EFFECT OF CHANGING OUTSIDE LAP, INSIDE LAP, TRAVEL AND ANGULAR ADVANCE

	ADMISSION	EXPANSION	EXHAUST	COMPRESSION
INCREASING OUTSIDE LAP	IS LATER CEASES SOONER	OCCURS EARLIER CONTINUES LONGER	IS UNCHANGED	BEGINS AT SAME POINT
INCREASING INSIDE LAP	IS UNCHANGED	BEGINS AS BEFORE CONTINUES LONGER	OCCURS LATER CEASES EARLIER	BEGINS SOONER CONTINUES LONGER
INCREASING TRAVEL	BEGINS SOONER CONTINUES LONGER	BEGINS LATER CEASES SOONER	BEGINS SOONER CEASES LATER	BEGINS LATER ENDS SOONER
INCREASING ANGULAR ADVANCE	BEGINS EARLIER PERIOD UNALTERED	BEGINS SOONER PERIOD THE SAME	BEGINS EARLIER PERIOD UNCHANGED	BEGINS EARLIER PERIOD THE SAME

FIG. 238.—Illustrating the interpretations of indicator cards.

Whistling or Grunting in the Cylinder or Valve Chests.—This is an indication that the lubrication of the pistons and valves is insufficient from the wire-drawn steam; it will only occur when running with light loads and will disappear when extra load is switched in and the engine takes more steam.

Water Hammer.—This commonly occurs in starting up. Thorough warming up beforehand and starting slowly with all drains open will remedy it (see also water in the cylinders).

The Cylinder and Valve-Chest Assembly.—The covers should be removed at least once in six months and the interior examined to see that the pistons and valves are secure on their rods and the cotter pins in place and for any corrosion or scoring of the working parts or their faces and seats, the wear on packing rings and the condition of the stuffing box of the intermediate head (tandem-compound).

The rod packings should be intact at all times or oil will work into the steam and be carried over to the boilers; that the packing is loose or worn will be indicated by escaping steam, this applies particularly to the high-pressure cylinder.

The correctness of the *valve settings* are indicated by the cards which should be taken weekly and made a part of the journal. In Fig. 238 are shown the accepted interpretations from variations from the ideal card. Normal good cards show that the design contemplates wire drawing after admission, early release, and considerable compression also that the initial pressure for the bottom end of the stroke is to be greater than that for the head end, which is to assist in handling that weight of the working parts which is not counterbalanced. It will often be found that the work done in the high-pressure cylinder is from 3 to 5 per cent in excess of that shown by the low-pressure cards and results partly from the extra work done in the bottom end of the cylinder, partly from diminution of pressure by condensation in the receiver (if used) and partly from the fact that the low-pressure valve is not controlled by the governor; in designs in which control of the low-pressure valve is introduced the percentage difference in work between the two cylinders is less, the device, however, is intended to lessen the steam consumption.

The available method of setting a valve is to lengthen or shorten its position on the rod, checking the setting by the results shown by the indicator card. The valve can be assembled on the rod most frequently in but one way; the lap and lead being constant for the design, which is for the normal steam pressure and prescribed number of inches of vacuum, it follows that the valve will not so well equalize the distribution of work in both cylinders at any other pressure and at any other condition of vacuum. Work-

ing at 20 per cent below the normal pressure on atmospheric exhaust the high-pressure cylinder may do two-thirds of the total work developed, and, thus doing twice the work of the low-pressure, the stress on the cranks is correspondingly divided and strain or bending of the shaft at the high-pressure end may ensue with heavy load; it is equally true of the low vacuum common to ship dynamo-room experience and is the potent argument for a separate, auxiliary condenser for the isolated service.

The Cross-Head.—It is the face of the cross-head guide bearing which develops the first wear in an engine. It is occasioned by the heavy friction of the reaction of the down-stroke thrust of the short connecting rod on the crank pin on a surface whose lubrication is at best difficult and unassured. Under running conditions the fault does not become apparent until lost motion produces an evident knock at the location and the necessity for lining up has become urgent.

In those cross-heads in which the blocks are held in jaws by straps, too much care cannot be taken that the strap nuts are well set up and locked; if the nuts become loose the hammering action of the piston, especially if assisted by water in the cylinder, can easily cause the nuts to strip the bolt threads, drop the nuts and strap into the base of the column, and catch the counterbalance of the crank when the clearance is small; on board one battleship such an accident broke the counterbalance and cracked the engine housing.

Careful attention should be paid to keeping the wrist-pin bearing blocks well lined, the pin and bearing well oiled, and to removing any knocking as soon as it develops.

A cross-head design which contemplates screwing the piston rod into a split sleeve and to be held by clamping is quite sure to prove annoying and defeat any but a tentative repair.

The Shaft.—The strain or spring or bend of a shaft is a serious matter as it involves heating of all brasses of the main bearings and of the cranks. Fortunately the bearings are placed as closely to the cranks as good clearance will permit and the accident is infrequent where the crank thrusts are assimilated, that is, where the work is fairly equalized between the cylinders. In a case of one small vessel on a speed trial the shaft of an engine was broken at the fillet of the L. P. crank; the accident has been attributed to the carelessness of an attendant in leaving open

the by-pass valve, thus creating a heavy preponderance of work in the L. P. cylinder.

The preservation of the truth of alignment of a shaft is necessary at all times, otherwise the bearings will heat and the armature be shifted from its proper position in the field and thrown out of magnetic balance.

Adjustments of the Shaft Itself when out of Line.—If the shaft is sprung or badly worn in the bearings, remove it and put it in a lathe between centers. If the shaft centers are not true with the surface of the ends make them so by scraping or by reaming by use of the steady rest. Try the shaft at each bearing and if sprung force it back as nearly to line as possible and turn down each defective bearing. If the shaft is worn oval, or flat in spots, or scored or tapered in the bearings, the only remedy is to turn down at each defective shaft bearing. The foregoing methods will insure a perfectly straight shaft, but require careful and skillful work.

In case a shaft is fitted to be coupled to the armature shaft the coupling must be faced, taking as light a cut as will clean up the entire face. Taking off too much metal must be compensated by liners when assembling in order to preserve the longitudinal alignment.

Adjustment of Bearings.—First take the diameter of each bearing on the shaft as the basis of alteration of the boxes. Many designs of boxes exist and each design has some difference in method of treatment. For boxes having white metal lining, or babbitt, the old lining should be removed, as a rule, if the shaft has been turned down or the lining is much worn. The lining is cut out by a cold chisel and the box thoroughly cleaned of oil and dirt by strong lye, benzine, etc., *the box not being removable.* The babbitting mandrel (or shaft in its absence) is then placed in position in the engine, and lined about 1/16 inch above the true center, to allow for filing and scraping and is firmly secured. The ends of the bearing boxes are walled up to hold in the molten metal, and the mandrel covered with lamp black or other suitable material which will prevent sticking. The metal used is commonly the Magnolia anti-friction metal, which is melted in a clean ladle and thoroughly stirred; it should not be mixed with other metal in the melting, but the old metal of the bearing can be melted over and used again by adding a little new; the metal

is to be heated sufficiently to flow freely and extreme heat should be avoided, when hot enough to brown a pine stick and trembling in the ladle, it is ready to pour. Before pouring, any likelihood of sudden chilling of the metal before it can properly fill the box is forestalled by heating the mandrel and box by an oil torch to about 200° F.; this precaution also effects a smooth and even bearing surface and partly overcomes the shrinkage. Pour the metal carefully, in a copious and continuous stream until the box is full, slacking down and adding a small excess to compensate for the shrinkage. When all the bearings are filled and the metal has cooled, remove the mandrel and trim off all surplus metal.

Next coat the shaft bearing, thinly and evenly, with a mixture of lamp black and machine oil of the consistency of pasty shoe blacking; place the shaft in place in the boxes and turn over a few turns by hand, then take it out; any high spots in the boxes should show a stain, and should be scraped or filed down; trial by the shaft is again made and the process repeated until all bearings show a perfect wearing surface. The method should be pursued carefully in all instances that, when completed, the shaft may lie truly in line in all of its bottom boxes. The oil grooves are cut before the final scraping.

The top half of the box is treated in much the same way as the bottom, the same process of fitting being followed. Particular care should be taken to keep the bore parallel with the joint, that the top half may joint fairly and the bore bear fairly on the shaft when the binder is put on and is tightened down. It is good practice to insert liners in the joint which can be removed as the babbitt wears.

When the boxes are removable, the new lining should be cast to be about ¼ inch or more smaller than the true bore and bored to size. Circular boxes can be chucked and bored true with the outer circumference; rectangular, or other than circular boxes are bored in the lathe by chucking or clamping to an angle plate; in either case, good lining up when placed in the engine demands careful work.

Bearing brasses made up of bronze, or other metal without white metal lining, are often lined up by building up on the bottom of the lower half until the center of the bore is higher than the shaft center, and the whole is then rebored for the proper

center. Sometimes the two halves are bored and lined with babbitt, but this is not necessary when the original type of brass has proved satisfactory. It is not advisable to repair badly worn brasses. The method of fitting of brasses to the shaft is the same as that for lined boxes.

When the shaft and bearings have been assembled in the engine the shaft should turn freely without appreciable lost motion. The engine is now run slowly under steam for a sufficient time to determine that no bearings heat; next the speed is increased and a run of an hour made without load, after which a light load is put on and gradually raised to the maximum, and the engine run under full-load conditions to determine that there is no heating or pounding. When the engine has been run under load for a few days, any lost motion should be taken up at the bearings and the bearings examined and refitted, this should be continued every three or four days until no longer necessary.

When the bearings are close, keep them snug but do not bolt down too tight.

When a babbitt is too soft it can be hardened before boring out by peening. Begin at the middle and strike lightly at first, increasing the strength of the blow until the metal is sufficiently hammered. This must be very carefully done, if at all, as with small boxes distortion is likely to result.

The following process will insure the soldering of Magnolia metal in cast iron, brass, etc.: Heat the box about 200° F. and wash over with soldering acid; next rub on tin, and then pour the metal.

Crank Pin.—There is no manner of use in temporizing with a hot crank pin. Shift the load, shut down slowly, cool off the pin and examine, refit and readjust the boxes. The crank should be tested from time to time with the hand whilst running and upon the detection of decided or uncomfortable warmth, the engine should be stopped before the babbitt is affected. For those cranks requiring brasses the metal should be a hard bronze and true bored in a lathe.

Water in the Cylinder.—This condition is much dreaded in engine operation since, as water is incompressible, the piston (and perhaps valve) strikes an unyielding obstacle in its path; the results on the heads or working parts of the engine, and the extent of damage is dependent on the proportion of the clearance which

the water occupies at the end of the stroke; it is usually evidenced by a pounding within, known as water hammer, should nothing else occur. The final cause is that water is entrained in the steam and is condensed within the cylinders or chests, but mainly in the high pressure cylinders of compound engines. It is anticipated in design by a large factor of safety (4 to 5) in the thickness of the cylinder walls and by relief valves at the top and bottom of each cylinder through which the water can escape. A separator is installed on the steam line whose office it is to remove all water ordinarily entrained in the steam.

The shipboard causes that may occasion that excess of entrained water which can reach the cylinders or chests in volume (not including the common case of starting up and which is to be handled by the drains) are:

Insufficiency in the Capacity of the Separator.—The average separator which is installed is too small in volume. The volume should be fully four times that of the cylinder which is being supplied, and for a plant, four times the volume represented by the aggregate volumes of a cylinder for each engine, that is, having four compound engines, the separator volume should be 16 times the volume of any high pressure cylinder; having simple engines, 16 times the volume of any one cylinder. This minimum volume has also the advantage of cushioning the steam pulsations and of preventing the often-noticed vibration of the pointer of the steam gauge dial. The ideal installation is an individual separator for each engine, having four times the volume of the engine's cylinder (as above); the nearer this ideal is approached the greater will be the protection afforded to that engine as regards water hammer.

The condensed water in a separator should show low in the gauge glass, or better, not show at all, if the trap connections are in good order.

Condensation in the Steam Piping.—This cause is most frequent in starting up and is the usual occurrence in connection with water condensed in warming up. The separator will accommodate the condensation in the piping back of it.

Foaming of Boilers.—What water the separator cannot eliminate must go on to the engine and the dynamo engines will get a large percentage of water from this source if installed low down in the ship. An especial case has occurred from the throwing of

heavy steam-driven machinery (such as that for turrets) on boilers which were of insufficient capacity for the total duty demanded.

Shifting of Boilers.—The changing of the steam supply from one boiler to another is a common cause of water-loaded steam. It will occasion no accident if notice is given to the dynamo-room in advance.

Carrying Too High a Water Level in the Boilers.—This will increase the moisture in the steam, for which the normal working of the separator is for the normal boiler level; a lower level will give drier steam.

The common commercial effect of water in the cylinder is the blowing off or breaking of the cylinder head or bonnet but the covers of a ship dynamo engine are now so strong comparatively that no case of yielding at that point has recently occurred. The results noted have been: broken piston; broken or strained piston and valve rods; broken cross-head; broken connecting rod (in one case the crank end coming up against and cracking the bedplate); strained shaft, in one case beyond repair.

Lubrication.—The lubrication of a journal effects three purposes: *the first* is that it prevents that heating of the journal and bearing due to friction which would expand both, seizing and stopping the motion; *the second* is that it reduces the mechanical losses of the engine due to friction; *the third* is that it reduces wear.

There are two methods of oil feed, gravity feed and forced feed.

The gravity, sight feed is accomplished by dripping the oil from oil cups or from a header filled from a suspended tank, the dripping into the feeder tube being in plain sight. This system requires extensive oilways in large bearings but the oil tubes can be tested before starting up by observing that the oil drips from the lower end of the oil tube on its bearing or into its pocket. The disadvantage of the system is that oil is not delivered in sufficient quantities to obtain the results of forced lubrication.

The great *advantage of forced lubrication* is that a large volume of oil is continuously forced through the bearings and around the journal. Its theory is that the metals are never in contact and it is intended that there shall be a flow, necessitating a clearance between the journal and bearing; hence if the pressure by gauge, about 15 pounds, is not maintained there is not sufficient amount

of oil to take up the clearance and lost motion and wear result. *For the mere purposes of lubrication* a pressure of from 1 to 3 pounds is ample, *but about 15 pounds is necessary to form the proper oil bearing.* A proper clearance between the bearing on the journals of working parts of engines, after they have been scraped to a fit, is an especially important matter with enclosed engines since the facilities for inspection are limited by the design of the castings; the solution resides in following the practice of adjusting the clearance by means of lead wires as used for main engines, where any cut and try method, involving possible heating and consequent delay, is obviously prohibitory. Lead wires of a diameter varying to suit the size of the bearing are laid on the journal and the bearing bolts set up hard; on slacking up the lead will be found to be flattened to the clearance dimensions and the thickness can be gauged. The lead wires are supplied in B. & S. G. sizes Nos. 10, 14, 16, 18, 20; fuse wire will answer in emergency. The mean clearance for journals is commonly about 0.01 inch; that for shafts, crank pins, and eccentrics (2½ to 6-inch diameter) is from 0.002 to 0.005 inch greater than the mean; that for wrist pins, valve stems, etc. (below 2½ inches diameter) varies about the same below the mean. To assist in the rapid and definite readjustment of the clearance in bearings, it is usual in repair work to separate the boxes and fill in the gaps with a set of liners. These liners are standardized in a set consisting of one each of No. 40 (0.003 inch), No. 36 (0.005 inch), No. 30 (0.01 inch), No. 24 (0.02 inch), No. 18 (0.04 inch) B. & S. gauge hard sheet-brass strips, shaped to conform to the edge of the boxes. The total thickness of one set is 0.078 inch. By using these in various combinations, any suitable clearance less than that existing may be obtained. Adjustments for length of connecting rods, valve rods, height of shaft bearings, and clearance of cross-head slides can also be made from the liners for the usual engine constructions. In fitting liners in bearings there should not be an excess of clearance at ends and sides through which oil may escape and reduce pressure.

The great drawback to present forced lubrication systems is that there is no means of assuring that the oil is feeding through the tubes, that is, that the tubes are not choked by gumming and foreign matter despite the pressure. Until a warmed bearing induces suspicion, it is assumed that the pressure will prevent the

condition. This points out the care that should be taken that all oil gets to the pump through the strainer only and not over the top or under the bottom; also that oil in the well which is apparently very dirty should be drawn off and carefully filtered.

A lubricating oil must have two qualifications: a density which will permit a flow in sufficient volume to fill the space between the box and journal; and viscosity, body, which determines its efficiency as a lubricant. Both are impaired by use, the density being increased and the viscosity lowered. To preserve working conditions and at the same time accomplish reasonable economy, about 25 per cent of clean (new) oil should be added to the dirty oil when running it through the filter.

No exact rule can be laid down as to the amount of oil to be supplied at starting; it will differ with the style of feed and make of engine. With forced lubrication a crank base should be filled to within 2 inches of the crank when at its lowest throw and the amount required be ascertained for the given case. The oil supply may be put in through the crank chamber door. All the tubes, chambers, etc., must be cleaned before, filling up and starting, from all dirt, sand, chips of paint, or other foreign matter, which can collect at the strainer and reduce the flow of oil below the necessary amount. In cleaning out the oil chambers, waste should not be used if practicable to use cloths; the lint from waste will clog up the pipes and strainers. Thoroughly clean out with lye all tubes, air vessels, and holes drilled in the shaft, cross-head, etc., not less than once every once in six months—to remove any gummy deposits. The first adjustment for the working pressure of 15 pounds may be made by the relief valve, if all other conditions are right, the excess returning through the by-pass pipe. The pressure gauge should be throttled by closing the cock to reduce the vibration of the pointer without reducing the readings.

The strainer should be lifted out frequently on a new engine and occasionally while using, to see that its surfaces are clear; this should be done often on starting up a new engine until it is certain that the tendency to clog up has been reduced to a minimum. Lifting the strainer does not interrupt the flow of oil, but it should be replaced as soon as possible to reduce obstructions in the pipe. The small holes in the top of the pump, for the return of any oil that gets up by the plunger, should be kept clear that the oil may have a free return to the chamber.

Any leakage of water through the stuffing boxes of the high pressure piston rod may overflow the oil chamber; the excess should be drawn off as required and put in the filter where the oil and water will be separated. The excess may be drawn off at the bib-cock in the piping from the pump. There is no gauge to indicate the excess but it may be noted when examining the strainer.

An excess of water mixed with the oil will lower the pressure on the system. Looseness of packings on the valve and piston rods will cause an excess of water and result in drawing the lubricating oil, which is thrown on the piston and valve rods into the steam spaces by the action of the vacuum. To obviate the effect, the packings should be examined frequently and adjusted as required.

The cool operation of the bearings may be noted by opening the door of the side of the engine frame, and feeling of the parts. The journals if in good order will not throw an objectionable amount of oil in the short time the door is open. If bearings are too loose or joints in piping are leaky, they must be tightened up If the check valves of the pump get worn in their valves or seats and reduce the pressure they must be refitted or renewed. In case of a lowering of pressure that cannot be compensated for by adjusting the by-pass, the bearing which requires taking up can be located by stopping the engine, disconnecting the pump plunger from its eccentric, and pumping up the pressure by hand; by doing this with the engine cranks at various portions of the stroke the slack bearing may be refitted and tested before use.

Arctic engine oil is a common supply for generating-set use and proves satisfactory. In first using this oil on engines which have been using other oils, the best plan is to fill the cups, etc., and run the engine at a moderate rate of speed that the oil may circulate and clean out all the channels. When the engine is stopped enough of the oil will remain to loosen all deposits. Run the first lot of oil about two days, then draw it off and replace with new oil filtering the dirty oil. After running the second lot four days repeat the operation and again fill up with new oil. When the filter shows clean oil begin using this on the engine. When the engines are in shape it is better to draw off the dirty oil from time to time, and filter, replacing with filtered oil; this,

with the forced lubrication, will keep the circulating system full of oil.

The best grease for grease cups is a good grade of Albany grease.

The oil in the outer, ring oiler bearing should not be quite up to the level of the bottom of the shaft or it may be carried over to the armature. The armature should always be carefully shielded from oil whether thrown on, coming from casing leaks, or by crawling on the shaft. **Never use any but new oil on this generating bearing.**

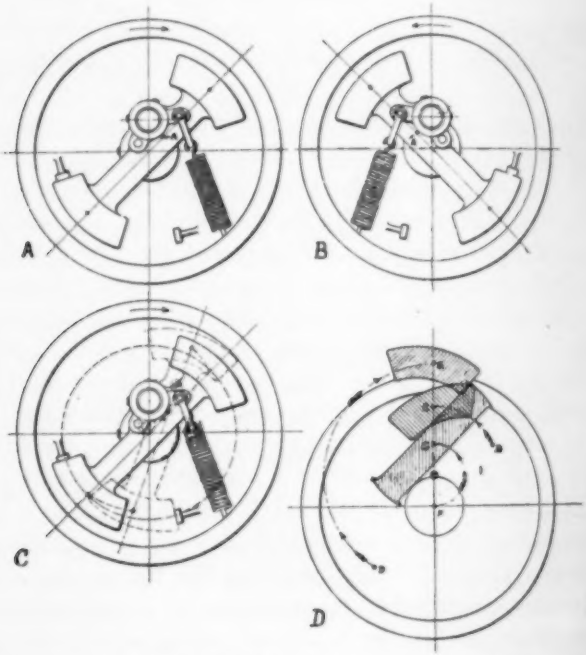


FIG. 239.—Diagram illustrating action of Rites' governor.

The Governor.—The type usually fitted to the engines is of the Rites design and, while simple in construction, contains features which require a proper understanding in order that the desired results in continued operation may be assurred.

The Rites' design of governor contemplates, primarily, the reduction to a minimum of the number of parts and journals in a

governor in order to obtain greater certainty and delicacy of action, including the faculty of regulating at the time when there is a tendency of the engine to change its speed rather than after the speed change has actually taken place. The governor action depends both on inertia and centrifugal force; the two are combined to mutually assist in producing the desired regulation.

In its simplest form the governor consists of a weight arm (Fig. 239) which lies in a circle on one of whose diameters lies the center of the shaft. The weight arm is enlarged at the ends for weights, giving it the appearance of a dumb bell from which is derived the colloquial term "dumb-bell governor."

The weight-arm pivot is located on a diameter about 45 degrees from that of the axis, and the stud, which acts as the eccentric and as the connection to the valve gear, is located between this pivot and the shaft center.

One end of the controlling spring is attached to the weight arm at a similar distance from the pivot and at about a similar angle to a line normal to that of the weight arm; the other end is attached to some fixed part, usually to the rim of the fly wheel.

The common assembly for either direction of rotation is as indicated in Fig. 239, *A* and *B*.

The adjustment of weight is so made that the center of gravity is at the point *A*, in figures A and B.

The part of the weight arm which produces the inertia effect is the longer as referred to the pivot, and is called the long arm; it will act very quickly at the time of a *sudden change of or a sudden tendency to change speed*, as in the case of the abrupt removal or increase of load. The short arm produces the centrifugal effect; the spring is attached to this end of the weight arm; this effect controls the *speed for gradual changes of loads*, changes of this nature not producing any effect on the long arm.

In Fig. 239, *C*, the weight arm is shown, in full lines, at its position of extreme valve travel and in dotted lines at its position of minimum travel. The arcs of travel of the weights with reference to the point of suspension of the weight arm are indicated by dotted lines.

It will be seen that the center of gravity of the long, or inertia, arm is at a reduced radial distance from the center of the shaft, reducing the value of its effect as the position of minimum valve travel is approached; also that the center of gravity of the short,

or centrifugal arm, moves farther away from the shaft center under similar conditions, and consequently the certifugal effect tends to assume the greater and more powerful element in the combined effect. The action of centrifugal and inertia forces of the single governor weight may be best understood by first considering separately each of the three parts, which form the weights, viz.: the weight on the short arm, the weight on the long arm, and the arm which connects them.

In figure *D*, these have been drawn disconnected from each other and their centers of gravities are supposed to have taken the shown positions relative to the point of suspension and due to centrifugal force. The center of gravity of the weight on the short arm starts from the normal position at *B* and travels to *C* in the same direction as in the usual operation of the governor in getting up to speed with load. The center of gravity of the weight on the long arm starts from its normal position at *D* and travels to *E* contrary to the direction taken in the usual operation of the governor in getting up speed with load. The center of gravity of the connecting arm starts from its normal position at *F* and travels to *G* in the same direction as in the usual operation of the governor in getting up to speed with load. It will be seen from this that the weight on the long arm has an independent tendency to move in a direction contrary to that of the weight on the short arm and of the connecting arm. Therefore, its movement in speeding up the engine in starting and getting up to full speed with load is due to the preponderating effect of the weight of the short arm and the connecting arm. These two weights, then, are the controlling factors in the proper action of the governor and control in reducing the valve travel in starting up and also on any increase of speed.

The weight on the long arm does not contribute to this effect but by its disposition is free to lag behind and assist in reducing the valve travel and engine speed on sudden increase of speed, and to forge ahead and assist in increasing the valve travel and engine speed on any sudden decrease of speed.

For the general case, within certain limits, adjustments of operation of the governor are obtained by the combined changes of the table on following page (see also Note 14, No. 121, page 260).

Function.		Parts to be Adjusted.					
		Weight on arms.				Spring.	
						Points of support.	
To be changed.	Change to be made.	Both.	Long.	Short.	Tension.	Outer.	Inner.
Speed.	More.	Less.	More.	Less.	More.	.....	Out.
Speed.	Less.	More.	Less.	More.	.....	.....	.....
Regulation.	Closer.	.....	.....	.....	More.	.....	In.
Regulation.	Less close.	.....	.....	.....	Less.	.....	Out.
Hunting.	Less.	.....	.....	More.	.....	.....	Out.

The Dynamo and Its Connections.

Notwithstanding the many details requiring careful construction, the dynamo, once it is designed and assembled, is a simple mechanical contrivance, if only from the small number of its working parts. Its management is reducible to a few simple principles, namely, the maintaining of designed speed, the maintaining of rated voltage, the maintaining of integrity of insulation resistance, and the avoidance of increase of losses.

Speed and Voltage.—The total electromotive force generated by an armature revolving in a magnetic field may for the purpose of this explanation be represented by the approximate formula $E = CMR$: in which C is the number of conductors cutting the lines of force; M is the intensity of the magnetic field; R is the number of revolutions per second, more commonly considered in its larger unit of revolutions per minute. C having been determined for any design ceases to be a variable; the matter of attention then reduces to the maintaining of the intensity of field and the speed in such a relation that their product shall always be constant.

The speed factor is dependent upon so adjusting the engine governor and its regulation that the speed shall be kept to that value at which it was designed that the armature should be revolved, that is, at rated speed.

The intensity of the magnetic field is obtained by a certain number of coils of wire, wound round the designed field core in which coils a fixed number of amperes of current is circulating: the product of the number of turns and the fixed number amperes is known as the ampere-turns, and this product must be a constant

to produce the required intensity. Since the number of turns is fixed in any dynamo by the designed field winding, the variable in operation is the current circulating in the field; therefore, for the given machine, the total electromotive force will be maintained if the speed is right and the current circulating in the field is as intended.

It is apparent that if the field current is too small, the speed must be proportionally increased; if the speed is too low the field current must make up the deficit. The limitations are: *first*, that the speed must not be increased to give that peripheral velocity which will cause sufficient centrifugal force to endanger the mechanical construction, and the governor should be adjusted to that rated speed of design in which this matter has been duly considered; *second*, that the field current should not be so increased as to unduly heat the coil.

Integrity of Insulation.—By insulation is meant not only the insulating coverings of current-carrying parts and the insulating material separating those current-carrying parts from contiguous metal, but also the air spaces separating connecting blocks and the like which may become bridged by conducting faults. The breaking down, lessening, of insulation resistance causing leakage, short circuits and grounds may occur from four principal causes, dirt, moisture (or water), oil, and heat.

The effect of dirt principally in the form of dust, is to absorb oil and moisture (or water) and form a conducting train to the framing or between points differing in potential, thus forming a leak, a short circuit, or a ground; or, in thus absorbing oil and moisture, to increase their particular effect on the insulations. Included in the designation of dirt is carbon and copper dust, substances which are continually thrown off from the commutator and which necessarily add to the conducting power of the train mentioned.

It is hereafter assumed in treating of faults that all dust, copper dust, metal chips, solder, and other foreign conducting matter are to be first cleaned off. **They must be the subject of first investigation when fault develops, the next investigation to be for effect of oil and moisture.**

The effect of moisture (or water) is to decrease the insulating qualities of insulations through the conducting properties of dampness, insulations not being satisfactorily waterproof; or

through direct connection between exposed conductors. An armature which measures low in insulation resistance may often test a megohm after wiping the ends of the commutator dry, the moisture having grounded the bars to the commutator shell.

The effect of oil, whether thrown on, by creeping, or when volatilized in the atmosphere and condensed, is not only similar to that of moisture, but it softens and injures the insulating constituents of the insulation, particularly rubber and varnishes. Oil necessarily forms more stable and lasting trains than moisture to occasion leaks, short circuits and grounds. Its effects are more lasting and less remediable than those of moisture.

The effect of heating is explained under the fault of that heading.

The Increase of Losses.—There are necessary losses in every dynamo, measured as the difference in energy between that transmitted by the engine shaft and that developed as electrical energy at the dynamo terminals; all are more or less accentuated in long service.

The bearing friction loss is kept at a minimum by oiling.

Windage is the necessary concomitant of the rotation.

Brush friction is held below an undesirable maximum by proper care of brushes and the lubrication of the commutator.

Hysteresis is reduced to a practical minimum in the design.

The C^2R losses or losses due to circulation in the current-carrying parts, and other heating losses, are treated of under Heating.

The Lost Volts.—The difference between the total electromotive force generated and the terminal voltage, or the lost energy derived therefrom which is necessary to circulate current through the armature and the series-field coils, and which may be roughly assessed as 2 to 3 per cent of the rated voltage, is a loss for a designed hot resistance of the circuits involved; this will be increased by any excess heating of these circuits and for the reason that more lost volts will be necessary to circulate current through the increased resistance which the heating occasions.

The summation of the necessary losses may be 10 per cent and more of the kilowatt output of a new dynamo, depending on its size. Increase of the losses means unnecessary expenditure of steam in the engine and coal in the boiler, and all remediable causes should be classed as faults.

Noise.—The general compactness and rigidity of the dynamo construction restrict proper noise to very few causes. A new machine may show a low frictional noise at the commutator occasioned by the fact that the mica insulations cannot be machined as smoothly as copper; but this disappears after short use and is not commonly met with especially when the commutator has been surfaced by grinding. The core teeth of slotted core machines sometimes produce a slight humming noise as they pass the poles but it is not common in modern constructions except at high speeds; it is more common in the small sizes when it exists at all.

Singing of Brushes.—This noise is the one which is oftenest noticed, and occurs generally from rough mica or a rough or dirty commutator. The nearer to the radial direction the brushes are set the more likely it is to occur under such conditions and it is therefore more common in reversing motors than in dynamos. Radial brushes give rather a squeaking noise than a hissing or singing. In many instances the hissing and singing is caused by dry, hard or gritty carbon brushes; this should be first examined for when the noise is detected; in other cases of noise at the brushes, cleaning the commutator and a little oil will stop it.

Vibration.—The bolting and assembly of a dynamo being assured, and bearings taken up, vibration is mainly a question of the sufficiency of foundations. The fault may aggravate any looseness in connections, may start bolts, may start connections at the commutator flange or for the circuits, may cause the machine to fail to generate by weakening or destroying the residual magnetism of the field coils, and may cause sparking, particularly when there are high or low bars. Vibration in a new machine may be due to an improperly balanced armature, one whose weights are not symmetrically distributed with reference to the shaft; this fault occurs from errors of construction and can be detected by resting the armature shaft on knife-edge rails and rolling the armature slowly, the heavier side will tend to turn down. In addition to the tendency to cause vibration an unbalanced armature is quite sure to prove faulty electrically.

Dynamo Faults.

As a general rule in dynamo and electrical faults it is loss of time to form sudden conclusions; the reasoning must be by a system of elimination until the actual cause for the effect is

ascertained, the elimination to be definitely determined in every case.

Prevention of well-known effects is the necessary element of care beforehand and includes such details of ordinary operation as cleanliness from dirt, copper dust, and foreign matter, about the machines; drying of oil and moisture; seeing that the dynamo is not overloaded and that voltage is not too high or too low; that oiling is properly accomplished, etc. When faults do occur, shut down the generating set, as a rule, until the fault is found and remedied.

Sparking.—The intense heat of the electric arc is the basis of results of this evil and its effects differ mainly in degree. In a new machine it is inadmissible if deleterious, a condition which is readily judged by the color of the spark emitted. It may be asserted as a general principle that a modern slotted core dynamo armature, fitted with carbon brushes, should show no sparking whatever from no load to 50 per cent overload, whether changes of load be made in one or several steps. The neutral line, the diameter equidistant between the magnetic pole centers, and the line of commutation, the diameter passing through the brushes when under load, may not correspond, but when the brush lead is once ascertained by trial, a new machine should require but little if any adjustment of brush lead thereafter for any stage of load.

Sparking is at once a troublesome and serious fault, causing heating, fusion, pitting, and scoring of the commutator at the brush contacts irregular and vibrating contacts are then set up which quickly aggravate the condition. The following are the principle causes and their remedies: those due to errors of design or of operation before delivery, should occasion the prompt rejection of a new machine.

The following causes of sparking are met with in ordinary service operation:

1. *Brushes Not Set at Best Point of Commutation.*—This is common with copper brushes on putting on or taking off load. Move the rocker arm slowly back and forth, and nearer to the edge of the leading pole pieces, until the sparking is arrested and the line of commutation ascertained; mark it with a chisel on the frame if for carbon brushes; a good machine with carbon brushes will develop a large non-sparking arc. Particular care should be taken that the point selected is that for least heating as well,

as there may be considerable heating and yet insufficient to cause an objectionable amount of sparking.

2. *Brushes Not Making Complete Contact.*—The fault will most frequently occur with an improperly trimmed brush, that is, one which is not making contact over its entire contact surface and this will create a similar condition to that mentioned in (1) above. Poor contact may be occasioned by the fact that the brush-holder will not turn or does not work freely (see also broken coils, end).

The best method of trimming or dressing carbon brushes is to fit a close, cotton band, ends sewed, around the commutator; to this band is glued a continuous layer of fine sandpaper, its edges close fitting; the brushes are then set on the sandpaper at running pressure and the armature slowly turned under power until all brushes are evenly trimmed. **Never use emery.** When the cotton band is removed all the loose particles of sand must be carefully cleaned off, the brushes aligned in the stud, and the springs adjusted to the designed pressure; too great pressure will unduly heat the commutator surface by friction.

3. *Brushes Not in Line.*—If the brush-holder design prevents a good alignment of the trailing edges of the brushes on the same commutator bar, for the same stud, the holders should be rejected. When occurring in service the brushes should be realigned at once. The design contemplates that the brushes shall span a fixed proportion of the commutator surface and this should be adhered to.

4. *Excessive Current in the Armature Due to Overload.*—This is not usual in acceptance tests, but may result from error in throwing the load switches, from a ground or leak in the connections, and from excessive voltage; these are to be ascertained and corrected. It may occur from several causes in service: *First*, from switching on load in the external circuit which is above the rated load of the dynamo; this should never be done, except in emergency. *Second*, from a short circuit, leak, or ground; good management imperatively requires that leaks, short circuits, and grounds shall be promptly sought out and the circuits and dynamo be kept free of them at all times. *Third*, from excessive voltage; this is a matter of attention throughout a watch and is controlled by adjusting the shunt rheostat to maintain the proper field.

5. *Commutator Out of Round, Rough, or Scored.*—A commu-

tator which is eccentric is detected by gauging when revolving; or by sighting under the brushes, when they can be seen to lift; or by the chattering of the brushes; or by noting the rise and fall of the brushes by touch of the hand. The fault is one of construction and, as turning down the commutator is the only remedy, it cannot be tolerated in a new machine because all possible latitude for turning down must be reserved for other future requirements.

A rough, scored, or pitted commutator, of which an irregular worn or furrowed commutator is the aggravated case, occasions sparking from irregularity of the brush contact and the spaces afforded to be arced over.

All causes are remedied by either smoothing or turning down the commutator accordingly as the damage is small or great.

Smoothing down is done by sandpaper (never emery) held to the commutator by wooden blocks. A convenient device consists of a two-handled composition frame across which is spread a sheet of flexible brass. The sandpaper can be stretched under this sheet and be held by clamps. Screws adjust the device for differences in diameter of commutator. The advantage of the device is its convenience of application and the regularity of its action on the commutator surface.

When mere smoothing will not answer, or the smoothing will not produce a cylindrical surface, the commutator must be turned down. It is to be preferably done in a lathe but may be done with the armature in place by taking off the rocker from its collar at the outer bearing and securing in its place a special slide rest, or by clamping the slide rest to the pillow block. Turning down is a delicate operation and requires a skillful hand; a slight slipping of the tool can score the commutator irremediably. A diamond-pointed tool must be used and the turning down be done by very fine cuts or the mica will sliver. The finish is made by sandpaper or a very smooth file; grinding by hand with a stone is preferable as the mica finish is better. After finishing, the copper dust must be carefully cleaned from the bars and mica insulations.

6. *Ground in Armature.*—The cause may be due to accident to the machine by which the armature conductor has been grounded to the core. Defective, damp, or impaired insulation will cause it, and as it is a similar case to a short circuit the through con-

nection must be due to some other ground to complete the circuit. The fault is detected by test for insulation resistance.

7. *Weak Field.*—The occasion of weak field may be that a short circuit may exist between the series and shunt; or either, or both are grounded. A ground will be developed by a test for insulation resistance. In the case of opposed fields the readiest method is to test the magnetic balance, but the first indication will usually be low voltage. The distinguishing effect of sparking from weak field is that the point of least or no sparking is shifted importantly from the usual point of commutation for the particular stage of load.

The following causes of sparking are not so common in ordinary operation but may occur:

8. *Short-Circuited, Cross-Connected, or Reversed Coil in Armature.*—This fault has the distinct symptom that the affected coil is heated more than the other coils. The sparking is periodic and the coil is likely to smoke or to burn out if the set is not shut down. If no short-circuiting foreign matter can be found or the insulation of the commutator is not bridged, the cause is attributable to a ground or a breakdown in the insulation and each coil should be tested out separately. The fault is often more conveniently detected by holding a file or tool between a pair of poles; a decided drag will be felt as the broken coil passes. This should be done cautiously and with a care that the tool is not dragged into the armature and out of hand. If the coil insulation is burnt, rewinding is necessary.

9. *Broken Coil in the Armature.*—This causes violent sparking from the high self-induction set up every time the broken coil passes under a brush, the circuit being abruptly closed and broken. An exactly similar result is produced if the break be not in the coil itself but at the point of connection of the armature coil to the lugs of the commutator bars, and is the more frequent as compared with a broken coil. In either case the commutator bars will probably be badly cut or burnt but no particular coil will be heated more than another, the flashing will be bad even when turning slowly. The fault can be distinguished from that of a high bar, or poor contact, or eccentricity by slowly turning the armature when flashing will immediately ensue if the circuit is broken, but will not in the other cases unless extreme and when the fault could be detected by the hand or even seen.

An emergency remedy is to solder together the ends of the contiguous connecting commutator bars but this should never be resorted to if it can be avoided, and in any event short-circuiting of other coils must be carefully avoided and seen to. A second remedy, and more advisable in emergency, is to echelon the brushes along the stud to short-circuit more bars at the point of commutation; it is apt to cause continued sparking and the basis of judgment must be whether that sparking is deleterious. The real remedy is to wind in a new coil. The eccentricity of rotation in practice may be due to a looseness of the shaft in its bearings, or the shaft may be down, or the armature may be pulled over by magnetic drag. Any lack of alignment in bearings or looseness of shaft should be first examined into.

A very bad contact can cause similar effects and symptoms to those of a broken coil and should be taken into the considerations of examination.

10. *One or More High, Low, or Flat Bars in the Commutator.*—This case is similar to a scored or furrowed commutator and occurs from a bar being higher or lower than others or worn flat on top. It occasions sparking from the effects of vibrating the brush off contact. A similar effect may be caused if the spring tension of the brush-holder is insufficient. For the actual case of low, high, or flat bar the remedy is to turn down the commutator.

11. *Unequal Distribution of Magnetism.*—The sparking from lack of magnetic balance is remedied, if it can be, by first spacing the brushes equally around the commutator and then shifting the field frame until the voltage between successive brushes does not differ more than one volt (see Inspection of Generating Sets).

The distinctive feature of this variety of sparking is that, with well-assured contact, there is a marked difference in the amount of sparking at the several brushes. Armatures fitted with equalizing rings are likely to be free from this effect.

12. *The "Flying Break or Cross."*—This term is applied to a broken coil or connection, or a loose connection, which breaks the circuit only when the armature is in rotation, the break being completed under the action of centrifugal force or vibration, but showing a continuous circuit when tested when the machine is at rest. It is a particular case of broken circuit which has the effect of flashing rather than sparking.

13. *Insufficient Carrying Capacity of Brushes.*—This error of

design will cause carbon brushes to heat, lower their resistance by the peculiar action of carbon under such conditions, and permit of increase of current in the short-circuiting coils. The brush area of contact should be designed for a minimum of one square inch for every 30 amperes of current.

Heating.—The heating of any part of a dynamo is always the occasion of increased losses in the machine, and as the heating tends to raise the resistance of all of the circuits, which in turn increases the heating, the cumulative result becomes important.

One of the causes of heating is the friction of the brushes on the commutator which, with present designs of spring pressure in order to get close contact, is likely to cause considerable necessary heating. There is no objection to using a little vaseline on the surface of the commutator, but it must be handled sparingly. Oil, as much as can be taken from the end of the shaft and applied by the end of the finger, will answer, but it must be borne in mind that carbon brushes are very porous and will take up the oil and increase their resistance.

The heating in any electrical circuit is equal to C^2R, and it is established that any temperature higher than 200° F. affects the insulations; it is probable that 190° F. is a high limit. As a test, the heating is considered to be safe if it is not uncomfortable to the hand for a few seconds; the test should be preferably made with the back of the hand than with the palm. *Bare metal feels hotter than other substances* but even then the criterion of comfortable temperature to the hand should obtain. If the heating produces odor or smoke, the safe limit has been exceeded, and requires that the machine should be quickly shut down if the load cannot be reduced. Ordinarily it is better to shut down for the reason that under these circumstances the location of the heating can be more readily determined. Since the heat may be conducted or diffused from its original source, if the machine is shut down and allowed to cool and then started up again with full field, that part which is the source of the heating will heat first and before any effect by conduction can occur.

Water and ice are never used for cooling any electrical machinery; air and ventilation is all that can be resorted to.

Heating of Commutator and Brush Gear.—This normally occurs from friction and will occur from sparking. Arcing across the mica is a serious case; if the burnt spots cannot be removed

a new commutator will be required as there is no other remedy. Heating will also occur from bad connections in the brush-holder and the dynamo leads, and is to be distinguished by the fact that the holder and cable feel hotter; the resistance of the circuit will test high. The remedy is to improve the connections.

Heating of Brushes.—Brushes in extreme cases will glow, ordinarily they will feel very hot; it is often the case that the brushes are too small, that is, have not sufficient carrying capacity for the use; sparking may ensue. The proper remedy is to put in larger brushes and to lower the brush-holder, if possible, so that the distance through which the current must pass in the carbon of the brush-holder will be materially shortened, due regard being had to safe clearance from the commutator.

Heating of the Armature.—This may occur from overload, the condition obtaining when the machine does not spark but is on the point of sparking and is similar to the case causing sparking. Short-circuited coils or broken connections at the commutator will heat the commutator.

Heating when due to steam or moisture will either show or the armature will feel moist. This condition is really a short circuit, and will show a low insulation resistance on test. There are two methods of remedying it. One is to place the armature in an oven at a low temperature (not to exceed 140° F.) and dry it out; on board ship a warm, dry, well-ventilated location will answer. A second method is to run about half-load current through the armature from another generator; this is attended with considerable danger if the voltages are not regular, and should not be attempted by any one except experts. In this method the armature should be turned slowly by hand or the shellac and varnish may run to the lower part of the armature. If the moisture is small the armature will dry itself if run on light load.

Foucault Currents in the Armature Core.—The core will feel hot and the armature will require greater than usual power to run it with a full field and no load. The power is to be determined by taking cards from the engine and comparing with those of ordinary operation at no load. The matter is usually taken care of in design by laminating the core, insulating the discs from each other by japan, and the avoidance of through bolts in the vicinity of the slots.

Eddy Currents in Armature Conductors.—The heating is due generally to the fact that the electromotive force is generated in one side of the armature before the other, and is overcome by laminating the conductors and sinking them deeper in the slots. The eddy current is more frequent with bars than with wires.

Reversed Armature Coils.—This is usually indicated by excessive current when running free though no particular coil is heated. It can only be detected by taking current from another machine and testing the deflection of a detector needle over the bars as the armature is revolved. The reversed coil will show a decided deflection of the needle as it passes. The remedy is to reconnect.

The "Flying Break or Cross."—The case is similar to that described under sparking.

Heating of Field Magnets.—This is usually due to excessive field current and is detected by the temperature of the coils. The remedy is to either decrease the voltage by rheostat or, if possible, to put in more wire, or to put resistance in series with the coil. The heating may be occasioned by a short circuit or ground. One coil will appear hotter than the others; the short circuit is not, however, in the hot coil, but in the other coils, for the reason that these coils, being short-circuited, are not receiving their proper proportion of the current, and the brunt is being thrown upon the coil which is heated. The remedy is to trace out the short circuit in the coils by test, and correct.

Field magnet pole pieces and cores will also be heated if their construction does not provide against Foucault currents, though this matter is not always taken into account as one of importance.

Moisture in the field coils is another cause of heating of field magnets, and should be tested out in the same way as for short circuit or ground, of which it is a necessary part.

General as to Heating.—Any fault which will occasion sparking will of necessity cause heating; and heating can be regarded as a remove from sparking only in degree and to be likely to end in sparking in time, in addition to its other deleterious effects in adding to the resistance of current-carrying parts—and consequent increased losses—and the destruction of insulation.

Low Voltage.—The meaning of this term is that the voltage cannot be maintained at the rated value; it is quite distinct from failure to generate.

As shown in the explanation of the formula $E = CMR$, the

maintenance of voltage is dependent upon speed and field current; the first test under this fault is therefore for the speed by tachometer, and should the adjustments of the governor fail to bring the speed up to the rated when the generator is under full-load current, it can generally be corrected by replacing the governor spring, which may have lost its initial tension from fatigue.

The speed adjusted, the source of the fault is due to the fact that the field is being robbed of its proper amount of current; which may be tested by connecting an ammeter in the shunt-field circuit, allowance to be made for increase of total current due to shunting. The loss of current may be occasioned by any of the causes mentioned under sparking for weak field. A common cause is leakage, short circuit, or ground in the shunt rheostat, which apparatus should receive its share of attention in measurements of insulation resistance. In an obstinate case of low voltage the cause was found in a train of oil in which copper dust had collected.

Failure to Generate.—This fault is that in which the dynamo produces no voltage at all or very little voltage when at required speed and all resistance has been thrown out of the shunt rheostat by moving the lever across the arc "High or Raise." These conditions having been assured the connections of the field should be closely examined for a broken circuit, short circuit, or ground and corrected. The probable cause will then be reduced to absence of or too low value of, the residual magnetism of the field cores. This fault is frequently met with in a new machine or in one which has been for a long time idle. Separate excitation from another machine or a battery will ordinarily suffice to overcome the difficulty. In many cases short-circuiting the armature and series coils will assist by circulating a current; the *short-circuiting should always be done with fuse wire of small capacity to prevent injury to the brushes or commutator.* Frequently the difficulty can be overcome by shifting the brushes backwards, causing the armature reaction to assist the field, or by pressing down hard on the brushes. If these methods fail, the field connections should be tested out to discover a reversed current in the field which could prevent excitation and yet be insufficient to reverse the polarity. Were the polarity to be completely reversed the dynamo would generate but the electromotive force would be

oppositely and though the pilot lamp would burn the voltmeter needle, being against the stop, will not indicate until the connections are reversed.

If the dynamo lowers its voltage importantly when load is switched on, and the field rheostat cannot correct it or requires a very unusual position, it is probable that the series and shunt fields are opposed on one or more coils; the erroneous connections should be tested out and corrected. A detector needle will often indicate the reversed coil.

If the polarity of the field is reversed, as shown by the failure of the voltmeter to indicate except when its connections are reversed, the engine should be stopped and the field excited in proper direction for 5 or 10 seconds by a current from another machine.

Modern machines having field cores constructed with cast metals wholly or in part will retain residual magnetism in the cores for long periods and loss of reversal is not likely; it may happen in paralleling if the equalizer switch is not closed. In the general case a test for continuity will determine the cause and excitation by a battery or from another machine will suffice.

The Operation of Dynamos in Parallel.

The design of the present standard switchboard contemplates the use of the output of all necessary machines to the fullest extent by operating those dynamos in parallel on the load as is usual in common commercial practice. It is an axiom in modern operative practice that *there is no advantage in running several units below their rated full-load capacity when one unit can carry the load.* The converse is equally true; *units should not be overloaded when others can be paralleled on the load.*

Ten years ago the paralleling of compound generators was considered inadvisable as being fraught with danger to one or the other of the machines; compound-wound machines are run in parallel nowadays with as little concern as for the shunt-wound generator. The reason lies in the better speed regulation and field control and the use of the equalizer in later compound generators and in a better understanding of the operation of, and relations existing between, such independent machines when paralleled on the load; and incidentally to the better protective action of the circuit breaker as compared with the fuse.

The compound generator being a combination of the series-wound and shunt-wound generator obeys the laws of both in its operation; hence a clear insight into the conditions of paralleling requires a knowledge of the separate functions of each.

The *series dynamo* is rarely, if ever, operated in parallel with another machine. Limiting the conditions to the placing of two series dynamos in parallel, it may be done provided:

I. *The two machines are exactly the same.* The mechanical difference incidental to construction of two machines of same design renders this result very improbable.

II. *Both machines are carrying heavy, or near full, load.* The usual practical problem would be to parallel in the machine to assist another which is, or is about to be, overloaded.

III. *Neither, or both the machines, is likely to be subjected to light load.* Should there be any difference in field strength between the two, that which has the stronger field will gradually overcome the other and assume all the load and the weaker will race away; or should the governors regulate unequally the machine taking the higher speed (and hence voltage) would assume the load and stop (and might reverse) the other driving it then as a motor, its current becoming an extra load on the first machine.

IV. *That the machines are connected through an equalizer.* This arrangement would probably be necessary in any of the conditions in I, II, and III.

V. *The fields of the two machines are interchanged.* That is, that the circuits are so connected that each machine excites the field of the other. This arrangement has been used practically in emergency but is not considered good practice.

The resulting conclusion from the unfavorable probabilities of paralleling series-wound generators is that it is rarely attempted. The use of the series-wound dynamo is now-a-days practically confined to arc lighting.

The shunt-wound dynamo can be paralleled with other similar wound machines with ease. The method and the effect of varying voltage may be illustrated by an assumed example. A 50 k. w., 80-volt, shunt-wound generator *A* is supplying 625 amperes (full load) to the external circuit and 10 amperes to its field; the voltage at the field terminals is 70, terminal volts at switchboard 80, and effective armature resistance 0.005 ohm.

The total electromotive force which *A* is generating consists of two parts, the 80 volts shown by the switchboard voltmeter, or terminal volts, and the volts necessary to circulate 625 amperes through its armature plus the 10 amperes in its field; the latter called the "lost volts," is evidently, $635 \times 0.005 = 3.175$ volts; call these lost volts three volts.

It is now desired to increase the external load to 1200 amperes and a like machine *B* is to be paralleled with *A*.

B's engine is brought to rated speed and the voltage adjusted *not to 80 volts, but to 83 volts;* for, from the well-known shunt machine characteristic, when *B* is paralleled with *A* and assumes half the load, 312 amperes, *B's* voltage will drop to 81½ volts, while *A's* will rise to 81½ volts due to the removal of half-load. The negative pole circuit breaker, or switch for *B* is closed to the negative bus bar and then the positive side to the positive bus bar. *A* and *B* will divide the current between them (of course, within the allowance of 20 per cent), each taking 312 amperes, the voltmeters of each machine showing 81½ volts. The voltage of both is now adjusted to 80 volts and each has a load of 312 amperes. The loads are then put on until 1200 amperes is shown on the line, or 600 on the ammeters of both *A* and *B*. It makes no difference after that in so far as voltage is concerned how the load is varied, *A* and *B* will automatically divide it practically equally; all that is required is that the voltage be adjusted by the shunt rheostats to be 80 volts for each machine.

Case I.—Assume that while both *A* and *B* were running at 80 volts and 312 amperes the voltage of *A* is raised by its rheostat to 83 volts and the voltage of *B* adjusted to remain at 80 volts (or what is practically the same thing *A's* voltage is made 3 volts higher than *B's*).

Neglecting the slight effect on the field of *B*, *A* would impress on the armature terminals of *B* a voltage of 3 volts, equal to and opposite in direction to, the drop (lost volts), on the armature of *B*, and *B* can supply no current; hence *A* must assume the whole load of 625 amperes and *B*, though still in parallel with *A*, will be running under the same no-load conditions with full field as it was before being put in parallel with *A*. Were this to have happened when both were carrying a load of 600 amperes, the heavy overload would have been thrown on *A* and would probably burn out its armature; it would not have been as much as

1200 amperes, however, as *A's* engine would slow and decrease its voltage. Accident to *A's* armature would be prevented in practice by the fact that the circuit breaker would trip or the fuse blow and prevent the overload on *A*, all circuits being then deprived of energy.

Case II.—Both *A* and *B* being at 80 volts and 312 amperes *A's* voltage is raised more than 3 volts in excess of *B's*.

A not only stops all supply of current from *B* but the excess difference above 3 volts will cause a current to flow in *B's* armature, oppositely in direction from that which *B* should normally supply; *B* becomes a motor operated by *A*, and *A* now takes not only the total load of 625 amperes but also the current which it is supplying to *B*. The motor action taken by *B* will turn its armature in the same direction as before and assist the engine in handling no-load conditions, causing the governor to throttle steam; the tendency will be for *B's* armature to race also, the increased speed operating to farther assist the governor in throttling steam. When the condition obtains that the motor action has caused the governor to bring the valve to minimum travel, steam leakage will probably operate to fill the cylinders and slow *B's* engine, still more decreasing the voltage of *B* until when the voltage of *A* exceeds that of *B* by 6 volts *A* is supplying 625 amperes to the external circuit and 625 amperes to *B*. In actual practice *A's* engine would slow and its circuit breaker open before any dangerous condition of overload could exist, but these facts apart the sequence of events would probably be as given.

From these cases it is evident that the engines of *A* and *B* should so regulate, and the control of their fields be such, that their voltage difference shall be kept within at least the limits of 3 volts; and that the circuit breakers or fuses should operate with certainty at the maximum of load for which they are adjusted.

When paralleling compound dynamos the likelihood of occurrence of the difficulties advanced is materially reduced instead of enhanced as was formerly supposed; it is effected by the use of a device known as the equalizer.

The equalizer is a connection which is made from the negative (usually) pole of each dynamo to an independent bus bar, called the equalizing bus bar on the switchboard; *it is essential that the*

connection be inside the series field, that is, between the series field and the negative brush.

The primary effect of the equalizer of two compound machines is that it places their series fields in parallel, keeping both terminals at constantly equal polarity. In a case of a machine *A* running at 80 volts and 625 amperes and a machine *B* running at 80 volts (shunt field only) and no load, and the equalizing switches of both machines closed and also the negative switch of machine *B,* the current passing into the series field of *A* has two paths: *first,* through *A's* armature; *second,* to the equalizing bus bar, thence through the series field of *B,* to the negative bus bar, and back. Hence, these paths being equal in resistance, one-half of *A's* series-field current will shunt through *B's* series field (though none passes through *B's* armature) and *A's* voltmeter will show a decreased voltage (the series field having been deprived of part of its magnetic effect) and *B's* voltmeter will show an increase of voltage; these voltages having been readjusted to show 80 volts for each machine, the total field of *A* and *B* will be exactly the same as when *B* is paralleled in by closing *B's* positive switch, that is, the new adjustment with the equalizer switch has prepared the fields of both machines for the conditions which they are to have when the paralleling is completed by closing *B's* positive switch, the effect of such closing being merely to throw 312 amperes on *B's* armature and 312 amperes on that of *A;* this will be immediately apparent from a rough diagrammatic sketch.

In practice, the change of engine speed will necessitate a re-equalization of voltage after paralleling; a qualification also enters from the fact that the total armature current does not flow through the series fields, part passing through the series shunt.

Method of Paralleling in a Second Dynamo of Same Capacity as that Already Running.—From a set of careful experiments are deduced the following rules for paralleling a second machine with one already running under load.

1. *See that the voltmeter is properly connected.*

2. *Bring the dynamo up to rated speed and voltage.* The speed under the no-load conditions will be evidently a little greater than that for full load, hence the governor should be adjusted for rated speed and the voltage for full load.

3. *Adjust the voltage of the machine which is under load two (2) volts higher than that of the line (rated voltage).* This is

to compensate for the decrease in its voltage when the equalizer switch is closed.

4. *Close the negative switchboard switch of the dynamo about to be put in parallel.* There will be no change of conditions due to this operation. It is frequent in commercial practice to run the negative lead straight, that is, without a switch, but the precaution of breaking the circuit by a switch is safer practice.

In interpreting the term "negative switchboard switch" the *switch to be closed must be that on the dynamo leg which has the series field.* Generally the connection is made at the negative (return) side, but if made on the positive side the "positive switchboard switch" would first be closed. This applies to the terms negative and positive throughout these directions.

5. *Close the equalizer switch for both dynamos.* The voltage of the loaded dynamo will decrease and that of the other will increase since their series fields are in parallel. Should the effect on the voltmeter of the machine to be paralleled in show a decreased voltage, it is evidence that the machine is not poled right; this, however, can scarcely happen because when it first showed voltage due to the shunt field alone the voltmeter should not have indicated (pointer thrown against the stop); the voltmeter connections should be examined and corrected.

6. *Adjust the voltage of the loaded dynamo about one (1) volt below and that of the other dynamo about one (1) volt above the rated.* This is to adjust the voltages for the effect of the unloading of the one and the loading of the other.

7. *Close the positive switch of the dynamo which previously carried no load.* Each dynamo will now take practically half the original load.

8. *Adjust the voltages of both dynamos so that each machine takes half the load if not already so provided.* The change in engine speed and the effect of change of load will probably cause the voltages of the two dynamos to differ.

9. *Switch in the desired loads in excess of that already carried.* For each new load switched in the load should divide itself equally between the machines. If the characteristics of the two machines are widely different it may become necessary to proceed again as in 8.

To Shift the Load from one Dynamo to Another.—Proceed

exactly as in the steps 1 to 8, inclusive, for **method of paralleling in a second dynamo,** then

9. *Simultaneously raise the voltage of the new dynamo and lower that of the dynamo which has been in operation until the ammeter of the latter shows no load* and the ammeter of the former shows full load.

10. *Open the positive switch of the dynamo which is to be stopped.*

11. *Open the equalizer switch and then the negative switch of the dynamo to be stopped.*

12. *Slow and stop the engine.*

To Throw a Dynamo Out of Parallel and Stop.—Proceed exactly as in the steps 9 to 12, inclusive, for shifting the load.

Paralleling of a Dynamo with Two or More.—The particular effect in case a third, or fourth, etc., dynamo is paralleled in with two or more dynamos already paralleled on the load is in the voltage effect produced when the equalizer switch is closed and when the positive switch is closed, *and in any case the operation must be completed for each unit before its successor is paralleled.* In the case where two dynamos are already running the effect on their series fields would be to lower them but one-third each approximately, while the third generator would receive two-thirds of its series field current directly the equalizer switch is closed; if a fourth dynamo were paralleled with three others, it would receive three-fourths total field current at once, and the series fields of the other machines would decrease but one-fourth; for five machines the effect would be four-fifths and one-fifth and so on. Experience with the machines and a knowledge of their individual characteristics will govern, but usually the rule of steps 3 and 6 for paralleling in a second dynamo can be safely followed.

Cutting out a dynamo would be practically as explained for throwing a dynamo out of parallel, at the same time adjusting the rheostats of all machines remaining on the load.

Paralleling Dynamos of Different Capacities (Sizes).—The resistance of equalizer and series field in series must be such that the drop across the series field and equalizer leads will be the same for each dynamo and be inversely proportional to the capacities, otherwise the voltages will not equalize and one machine will assume more load than the other; this assured, it is better to lower the load of the larger machine until the half value will not

exceed the full-load capacity of the smaller dynamo; paralleling is then accomplished as in other cases, all increase in load being thrown on the larger machine by regulating the rheostats so that the load of the smaller may not exceed its full load.

The practice requires close attention, and is, for the general case susceptible of accident and inadvisable.

To Start a Generating Set.—Before starting the following should be carefully examined into and adjusted:

That the circuit breaker is open.

That the separator and trap connections are right.

That the working parts of the engine are well connected up and cotters in place, especially about the cross-head and crank connections.

Before putting on the cylinder heads and valve-chest cover remove any tools, chips, or dirt which may have lodged in or dropped into the cylinders, chests, or steam ports. Carefully examine the setting-up bolts and their nuts and locking nuts, noting that cotter pins are in place; all packing; bearings; oiling system and connections; oil pumps; holding-down bolts of engines, dynamo, and outer bearing. See that the strainer is on the suction of the oil pump and the rings of the ring oilers in their seats. Turn the engine slowly by hand and overlook all working parts. Fill the oil reservoir with clean (new) oil to within 2 inches of the crank when down. Do not close the doors until the engine has been seen working at one-third speed at least. In short, the smaller details of both engine and dynamo should be examined as an assurance against accident or injury.

See that the oil reservoir in the base is filled to the level mark on the gauge glass; that all grease cups are filled and the feed set up; that the reservoir of the ring oiler bearing is full to the mark on the gauge glass; that the oil-pump connections are in order and the strainer in place. (If gravity feed, see that the tank is full, or fill the oil cups, and try the drip cocks.)

Open the main valve on the main steam pipe and see that the boiler pressure and pressure on the engine line is up to normal and that the condenser is operating on the exhaust line.

1. Open all drains to cylinders, separators, and traps.

2. Turn the engine to the dead center by hand, open the engine stop valve a very little, open the throttle and by-pass valve slightly and let the engine warm up for at least 5 minutes; then

turn the engine to the other center and repeat the warming for the same length of time. (When there is but one attendant, it is better at this time to put in resistance in the shunt rheostat by moving the shunt rheostat well over on the "Lower" side in order that when the engine is started he will not have the engine and voltage to take care of at the same time.)

3. Open the main exhaust valve (on the main line).

4. Close the throttle valve.

5. Open the engine stop valve.

6. Open the throttle again gradually until the engine, started with the starting bar, works at low speed and keep it at this speed until all water is worked out of the cylinders as noted by the water hammer. A piston rod or piston may be broken or injured by starting the engine should there be any water in the cylinders.

7. Close the drain valves and open the engine exhaust valve. When other engines are running and exhausting into the same main exhaust pipe, closing the drains and opening the engine exhaust must be done coincidentally that the vacuum may not be too greatly affected; were the exhaust valve well open before the drains are closed the condenser would be open to the atmosphere.

8. Open the throttle gradually until wide open. Always run an engine with a wide open throttle and let the governor take care of the steam supply.

While the engine is turning over the dynamo is taken in hand and it is necessary to see:

That the circuit and main fuses are in good order and well secured.

That the dynamo connections, and to switchboard are intact.

That the brushes are properly trimmed and aligned. That the generator is not damp, or dirty, or spotted, or streaked with oil.

If the generator is provided with copper brushes, the brushes should be off the commutator before starting and not let down until the armature is at speed. Carbon brushes should be let down on the commutator before the engine moves; with copper brushes, however, the engine should be first slowly moving, otherwise should the engine reverse when first turning over, due to back pressure or error in handling the starting bar, the brushes and holders may be injured.

9. As the generator comes up to voltage adjust the shunt

rheostat to bring to the rated voltage as indicated by the pilot lamp.

10. Close the circuit breaker (or main switch) and adjust the voltage shown on the voltmeter by the shunt rheostat.

11. Throw on load gradually by closing the circuit switches, keeping up the voltage by the shunt rheostat, until all the desired load is on.

Copper brushes must be shifted in the direction of the armature rotation, as the load is put on, as may be necessary to avoid sparking.

The dynamo-room circuit is usually switched in first to light up as soon as practicable.

To Stop a Generating Set.

In the usual ship case one set is shut down when another is started; hence:

1. Throw the load gradually from the set to be stopped by regulating the voltage by the shunt rheostat, until all load has been shifted to the other set.

2. Open the circuit breaker (or main switch).

3. Close the throttle about half way.

4. Close the exhaust valve first and then open the drain valves.

5. Close the throttle.

6. Close the engine stop valve.

The exhaust must be closed before the drains are opened or the condenser will be open to the atmosphere.

In testing, the throttle is usually gradually closed without breaking the load, thereby keeping up the pressure in the cylinders to clear out water.

The load should always be broken in steps. For testing the governor (engine regulation) it is permissible to break the load from full load to no load and the reverse, but such strains on the governor and working parts should be limited to test only; the occasions when, from the blowing of the fuse or opening of a circuit breaker, the actual sudden loads occur are those for which the test is intended to demonstrate a preparedness.

If the dynamo is fitted with copper brushes they should be raised from the commutator as soon as the engine has stopped.

Laying Up a Generating Set.

When the engine is not to be run again for a week or more, the cylinder heads and valve chest covers should be removed and the cylinder and valve-chest walls coated with a thick layer of vaseline to prevent the piston and valve from freezing (rusting) to the walls.

Should it be the expectation that the generating set will not be run for two or three months, or in the case of a ship going out of commission, remove cylinder heads, valve-chest covers, and all soft and metallic packing; take out the pistons and the valves (marking the setting on the stem), put a thick coating of cylinder oil on the cylinder and valve-chest walls and put back the pistons and valves; put the cylinder heads and valve-chest covers on and set up loosely, allowing the air to circulate and any condensation to escape or evaporate; coat all bright surfaces thickly with cylinder oil, including valves and valve stems, pistons and piston rods, and the piston rings. *If the generating sets are to be shipped to a distance,* white lead and tallow will last better than cylinder oil. Both metallic and soft packing have been found to have rusted a piston rod for a depth of 1/32 inch after one month, and the packing should be removed if the engine is to be laid up or shipped.

The Motor.

Dynamos and motors are so similar in their construction, and one machine can be so generally used for the purposes of the other, the difference being mainly in the adaptability for a specific use, that they have much in common and especially as to faults.

The chief accident to shunt motors is the burning out of the armature or field coils from overload in the circuit. The methods of avoiding it are:

1. A careful elimination of leaks, short circuits, or grounds.

2. The use of a circuit-breaking device which will operate either *on overload or on failure of the line voltage.*

Overloading requires no further explanation than that the excessive current heats and chars the insulations.

Burning out from failure of the line voltage occurs in this way: the starting rheostat resistance is tapped at a series of points or blocks. In starting, the rheostat lever, which is connected to one terminal of the supply circuit, is moved slowly from point to

point, or block to block, gradually decreasing the resistance in circuit, permitting more voltage on the armature of the motor, until the lever gets to the last block, when all the resistance due to the rheostat is cut out and the current leads directly through the lever to the armature, giving it the total voltage of the main line. There is usually a switch in the circuit. If a break in the main line occurs, thus shutting off the motor supply, the rheostat lever should be immediately placed on the "off" block, where it was before starting; otherwise, when the supply is renewed, the motor suddenly receives the full voltage of the line before it has had an opportunity to start, receives an overload, as no back electromotive force is being generated, and the armature is burned out.

Back electromotive force is readily understood from a brief explanation. Inasmuch as the armature of the motor revolves in a magnetic field, it becomes a dynamo to the extent of the number of its coils, the intensity of its field, and the number of revolutions ($E = CMR$), and of its own accord generates an electromotive force opposing that coming from the line; the current to be carried by the armature is by design based on the difference between that of the supply line and the back electromotive force generated by the motor, and an armature burns out when suddenly subjected to the full electromotive force of the main line for the reason that its winding was not designed to carry such high currents as will flow.

In most cases of burnt-out armatures which have been investigated it has been found that the rheostat lever was left on the full-voltage block ("armature stop").

The burning out of the starting rheostat occurs almost invariably from attempts to use it as a speed regulator. The resistance wires are designed to be subjected only to heating effects for the short time necessary in starting, and it follows that if the lever is permitted to remain on any block intermediate between the first and last, the resistance wires will gradually overheat and finally burn out. When speed regulation is desired a controller of special design whose resistances are designed to stand the necessary heating should be employed.

Faults.—The causes of faults in a motor are similar to those of a dynamo and are similarly remedied.

CHAPTER XIII.

ELECTRIC FIXTURES AND LANTERNS.

The regular fixtures and lanterns are those used for lighting various compartments and spaces on board ship and include the following:

Fixtures.

Ceiling fixtures, Nos. 1 and 3.
Ceiling fixtures, Commercial.
Bracket fixture, single.
Bracket fixture, double.
Overhead bunker fixture.
Drop fixture.
Deck fixture.
Bulkhead fixture.
Bunker fixture.
Electrolier.

Lanterns.

Deck lantern.
Battle lantern.
Cargo reflector.
Desk light.
Portable N. W. T. and W. T.
Magazine lantern.

The special fixtures and lanterns are those used each for some specific purpose other than mere illumination of spaces on board ship and include the following:

Masthead lantern.
Top light.
Towing light.
Range light.
Diving lantern.
Binnacle light.
Telegraph fixture.
Stern light fixture.
Five light reflector.
Night signal lantern.
Side light, red and green.
Side light, red.
Signal lantern, green, red and white.
Peak light.
Truck light.
Turret hood fixture.
Semaphore, wigwag.

The torpedo-boat fixtures and lanterns are those used only for torpedo-boats and destroyers, and for special uses and include the following:

Masthead lantern.
Signal lantern, green, red, and white.
Binnacle light.
Wigwag signal.
Side light, red and green.
Truck light.
Magazine light fixture.
Night signal set, 2-light.

Ceiling Fixtures.—The former types and as sometimes still met with are four in number and designated as Nos. 1, 2, and 3, and commercial.

The No. 3 is the same as the No. 2, excepting that the No. 3 has a band of open filigree work placed above the plain ring of the No. 2; the former No. 3 fixture has been discarded, and a new No. 2 designed to replace the former No. 2.

The present standard No. 1 and No. 3 have been designed with reference to use with both conduit and molding, doing away with the wooden blocks that were necessary for securing the former varieties.

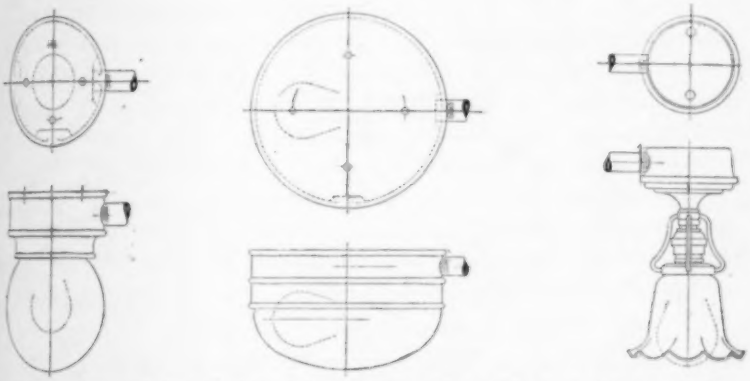


FIG. 240.—From left to right; ceiling fixtures No. 1, No. 3, and commercial.

Ceiling Fixture No. 1.—The fixture with its globe, is as shown in Fig. 240.

It consists of a brass casting one part of whose side walls is thickened to 5/8 inch, forming an interior boss for the tap hole for the conduit. Two similar bosses are cast on the side walls 90 degrees from the conduit entrance: one, as may be most convenient for the particular run, is tapped for the conduit for the switch wires to avoid a T on the outer conduit line leading to the fixture. The fixture is secured in place by four screws through the bottom of the base. The globe ring is in one with and smaller than the base; it is internally threaded to take the threads of the globe.

The globes are usually frosted; the frosting should be done on the inside surface of the globe, the outside being perfectly smooth; if frosted outside the collected dirt interferes with the illumination

and the globe is difficult to clean. The type-A socket is used, which is cushioned against shock by interposing a packing, or gasket of 2-ply cotton-insertion sheet-rubber packing between the bottom of the casting and the porcelain. A similar gasket fits under the edge of the spherical globe and packs the fitting water-tight. The entire inside of the base is painted with white enamel. Ceiling fixtures No. 1 are usually finished in bronze.

Ceiling Fixture No. 3.—The fixture with its globe is shown in Fig. 240.

It consists of a brass casting, one part of whose side walls is thickened to 5/8 inch, forming an interior boss for the tap hole for the conduit. Four screws through the bottom secure it in place. The fixture switch is provided for by using a branch box on the

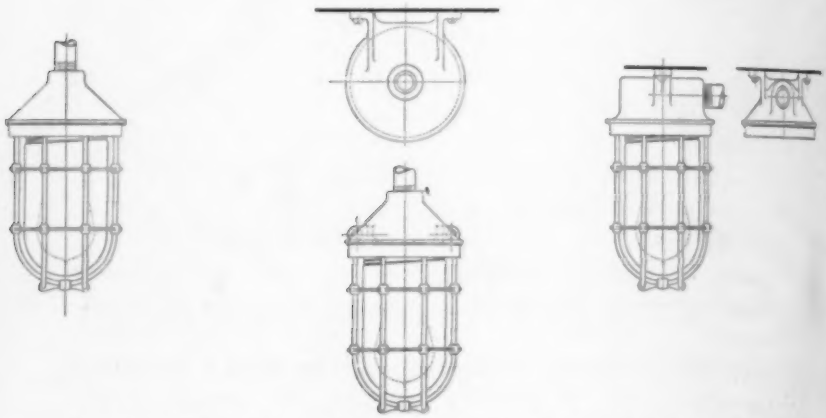


FIG. 241.—From left to right; drop fixture, bulkhead fixture, deck fixture.

conduit line. The globe ring is in one width, of the same diameter as the base, and is internally threaded to take the thread of the globe. The socket used is the standard metal type which screws on an arm attached to the base, the arm being perforated for the passage of the wire to the socket contacts.

The globe is packed water-tight by screwing against 2-ply cloth-insertion sheet-rubber packing ring. Globes for this fixture are of clear glass, except when used in quarters. When frosted, the frosting should be on the inside.

The interior of the base is painted with white enamel, especially the inside of the bottom of the base which acts as a good reflector.

Ceiling fixture No. 3 is much more efficient for overhead lighting than No. 1, as the best effect of the lamp is utilized in the flat position and the reflector economizes the lost rays.

Drop Light, Deck Fixture, Bulkhead Fixture.—The three types are colloquially known as the steam-tight fixture. The primary idea of the design of this line of fixtures is to obtain a similar construction for all, whose guard will be safe against the deformation and destruction incident and common to the weak flat wire guard heretofore in use, and to combine in three types all necessary to the various uses.

The difference between the three exist only in the base, the remaining parts being the same for all.

The drop fixture base (Fig. 241) is tapped for a central boss, the conduit acting as the support or pendant; no securing lugs are necessary as the fixture is to be set flying. It replaces the old type of steam-tight fixture, and its convenience in high fire-rooms where it can be run down for overhead lighting or for lighting instruments and gauge glasses will at once be recognized.

The deck fixture base (Fig. 241) has a boss all the way across the top; one side to be tapped for the wires leading to the lamp; the other for the switch wires when the switch is to be installed on the opposite side of the light, a convenient method.

It is designed to replace the former type of steam-tight fixture also, and to be used instead of the drop fixture where it is desirable and necessary to use all available height overhead; or where a conduit lead comes from the side; or where it is desirable to bring in the conduit at the side rather than make the bend necessary for the drop fixture (bends increase the difficulty of drawing wires). This fixture is used preferably for overhead lighting of berth decks, passages, under fire-room and engine-room gratings, etc. (provided there is sufficient head room as the fixture extends below the beams), giving good dispersion and rendering fewer lights necessary.

The bulkhead fixture base (Fig. 241) has its boss at the top and the lugs are placed at the side. This arrangement of the lugs permits installing the fixture against a flat surface. It replaces the former type of bulkhead fixture for side lighting of berth decks; for reading lights for the crew; for lighting the decks under the hammocks after overhead lights (which would shine in the eyes of the occupants of the hammocks) are extinguished; for

side lighting of engine and fire-rooms and about auxiliary machinery; for lighting spar decks; for overhead lighting when the head room is not sufficient for the deck fixture; and for overhead lighting in many spaces where the ceiling fixture No. 2 has heretofore been used.

As the beams interfere with the dispersion of light from a bulkhead fixture more of them are required for overhead lighting of a space that would suffice for the deck fixture; they are not used if sufficient head room for the deck fixture is available, handling gun gear, etc., being taken into consideration. Their use in a horizontal position is, however, often open to objection, as there is a liability of water entering the interior of the globes if not kept screwed tight.

The base is a conical shaped, hollow, brass casting, having an internal flange and rib; a type-A socket secures by two screws to the rib, and on ring and flange is placed a wide ring of 2-ply cloth-insertion sheet-rubber packing which forms a cushion for the socket and a gasket to water-tight the globe.

The guard is made of four 3/16-inch brass wires which are bent to shape and inserted at the top through the four arms of a brass (cast) guard flange. The guard is threaded internally to screw to the outside of the threaded collar and is cast with lightening recesses between the solid web through which the holes for the wire of the guard are threaded. The wire is soldered where it passes through the guard rings. The base is internally threaded for the thread of the glass globe.

The globe is made of clear flint glass 6 11/16 inches long; a variation of 1/16 inch, either way of this dimension is allowed.

The interior of the base is painted with an insulating varnish. The guard is finished in dark bronze and the outside of the base is painted to correspond with that of the compartment; if white, the paint should be enamel paint.

The Bracket Fixture.—*The single bracket type* is shown in Fig. 242. The arms are curved brass tubes into which is screwed a shouldered-shaped nipple, threaded for securing a standard metal socket. The other end of the tube is brazed into a filleted, cast brass, conical section, drilled for four screws which secure it to the base.

The base is a brass casting having a boss cast in the side walls for the conduit, and two smaller bosses, either of which can be

tapped for the conduit of the switch wires. Cast with the base are four bosses which are tapped for the screws holding the cast brass section. A collar carrying the shade holder slips over the outer threaded end and is held by the socket; three thumb screws on the rim of the shade holder hold the shade in place. The shade is of the fluted pattern.

The double bracket type (Fig. 242) is a modification of the single bracket for two lights, the arms being set out at an angle from the crown of the base.

All bracket fixtures are finished in dark bronze.

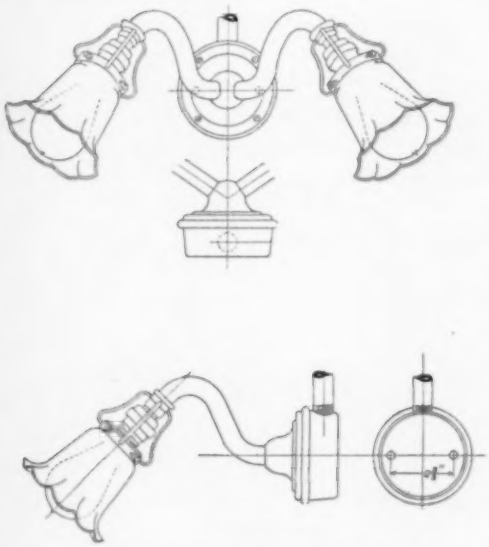


FIG. 242.—Double and single bracket fixtures.

The commercial ceiling fixture (Fig. 240) is a modification for overhead lighting of the single bracket fixture construction and is used to replace ceiling fixture No. 1 in various locations.

The Electrolier.—This is a modification of the commercial ceiling fixture in which two, three, or four arms of the bracket fixture are attached to the crown of the base for two, three, or four lights. But one tap is made for the conduit.

The Bunker Fixture.—This type of fixture is shown in Fig. 243. The fixture consists of a cylindrical brass casting, to which a removable cover is attached by four stud bolts, the joint being

packed by a 2-ply cloth-insertion sheet-rubber packing. The cover has cast ribs for stiffening. On the back of the cover is a screw cap, also packed water-tight at the joint; this cap can be unscrewed for examination of the condition of the lamp and the glass base.

Cast in one with the cylindrical casting is a flange which is gusseted to the main casting for strength; this flange is drilled for twelve $\frac{3}{8}$-inch by $\frac{7}{8}$-inch bolts which secure it to the bunker bulkhead, the flange being set back sufficiently on the cylindrical casting to allow its face to project beyond the inside (bunker side) of the bulkhead.

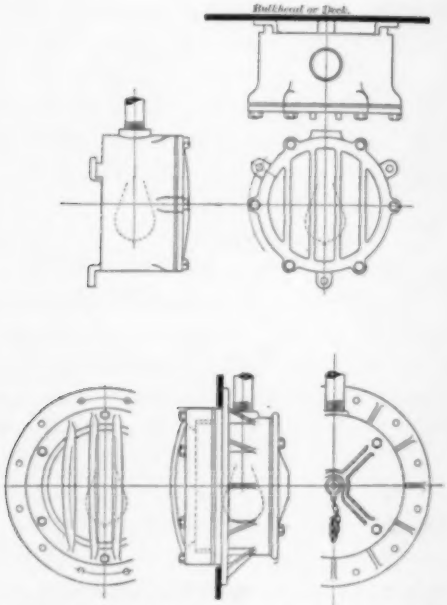


FIG. 243.—Overhead bunker fixture (top) and bunker fixture.

On the bunker side the fixture has a follower ring, across whose face are cast four strong vertical guard ribs, to protect the glass face; these are disposed radially on the horizontal axis to lessen obstruction of the light. A glass disc, similar to a deck light and one inch thick is inserted between the outer flange of the follower ring and the face of the cylindrical casting and made water-tight by sheet-rubber packing rings front and back. A type-A socket is used, cushioned by a packing ring, and secured on the top of the boss which is tapped for the conduit.

Overhead Bunker Fixture.—The design of the preceding bunker fixture is such that it cannot be installed overhead where it could light the bunker more efficiently; for this purpose the overhead bunker fixture (Fig. 243) is used, though difficulty of access prevents the general use of a fixture of this type where the face must be taken off to obtain access to the lamp for renewal. The overhead bunker fixture is only used for the overhead lighting of bunkers; its interior is painted with white enamel.

Deck Lantern.—The deck lantern (Fig. 244) is a battle lantern without a shade and shutter. The top is a brass casting having a boss and stuffing tube, taking a D-13 gasket. Two cast lugs on

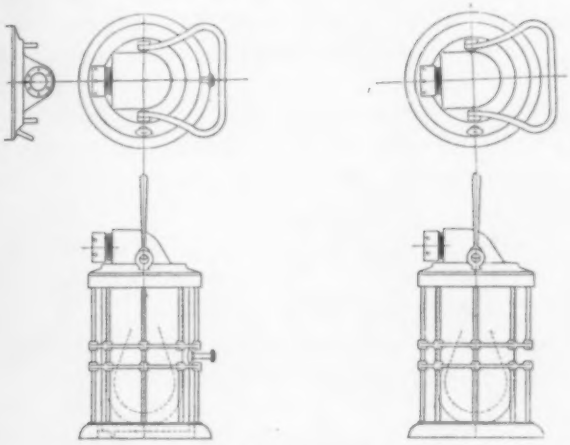


FIG. 244.—Battle (left) and deck lantern.

the top secures the bail. Against the inner face of the top is secured a type-A socket. The inner side of the side flange is thread for a globe of the same type as used in the steam-tight fixture.

The guard consists of a ring screwing on the outside edge of the flange of the top to which are riveted the rods made of brass wire, 3⁄16-inch diameter. These rods pass through two guard rings, to which they are soldered, and their ends are riveted to the base ring, which is about one inch wide; the bottom of the lantern is thus open permitting the light to shine down as well as through the side of the globe.

The lantern is for ordinary use about decks as a hand lantern.

It is wired up with double conductor, plain, wire and finished with the standard water-tight attachment plug.

One-half of the number of deck lanterns allowed a vessel have a length of conductor of 25 feet, one-fourth, a length of 50 feet, and the remaining one-fourth, 100 feet.

The fixture is finished in dark bronze.

Battle Lantern (Fig. 244).—The battle lantern is a lantern adapted for use around guns, etc., in night action.

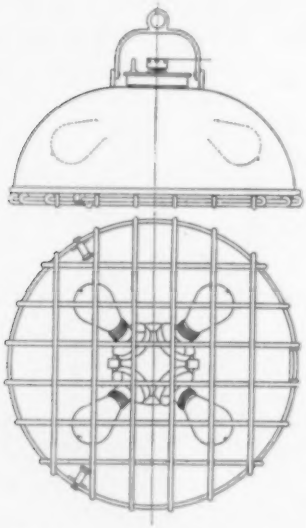


FIG. 245.—Cargo reflector.

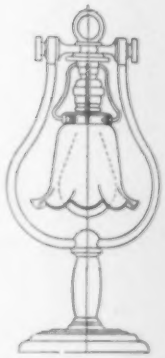


FIG. 246.—Desk light.

Within the guard of the battle lantern, for one-half the circumference and for the total length of the lantern, is rigidly secured a brass shade shutting off all light for that section; for the remainder of the circumference is a similar sheet of brass, acting as shutter by sliding in guides, and controlled by a knob extending out between the guard rings. All side light can, therefore, be cut off at will, or half the side light is utilized as desired. The bottom lighting can also be controlled by a hinged shutter which closes up against the base ring. Its remaining construction is the same as that of the deck lantern.

This type of lantern is wired up with double conductor, plain, and finished with a water-tight attachment plug; the length of

wire is that best adapted to the locality of the particular gun. The finish is dark bronze.

Cargo Reflector.—The cargo reflector (Fig. 245) consists of a dome-shaped reflector of spun brass whose edge is wired. A wire guard made of a mesh of 12 round brass wires, tied, or clipped, and soldered at the cross, hinges to the edge, and is secured by two spring latches at 135 degrees from the hinge center. The dome is riveted and soldered to a top casting which is tapped and threaded for four type-A sockets, the sockets setting at about 45 degrees wth the vertical. A cast cap is fitted centrally with a stuffing tube and gland, the tube taking a D-13 gasket for packing the single, double conductor, plain, wire used. Secured to the top casting are two lugs on which the bail hinges. The interior of the dome of the reflector is painted with white enamel. The outside is in dark bronze.

Four 16 candle-power lamps are used in this fixture; each socket is first wired separately with double conductor plain, the ends are soldered in parallel, and to these are soldered the double conductor plain, of the fixture conductor, all joints being well taped. The conductor is 100 feet in length and finished with a water-tight attachment plug.

This type of fixture is used for lighting gangways, over coal barges, lighters, etc., when working at night and an especial amount of illumination is required, and for illuminating holds and hatches in handling cargo.

Desk Light.—This fixture (Fig. 246) consists of a heavy base into which is screwed a fluted handle to which is screwed a knob. Into this knob are screwed the two pedestal arms; the upper ends of the arms are bored for the ends of the cross bar which is fitted with clamping nuts. All joints are brazed.

The lamp holder fits through the central ring of the cross bar and is detachable. It consists of a brass casting into which is screwed a ring for hanging up the lamp on cup hooks when off the pedestal. The lamp can be swung from side to side when on the pedestal and clamped at an angle, however it may be suspended. The socket is of the standard metal type and clamps the shade holder whose ring has three thumb screws securing the shade. These shades are the same as those used for the bracket fixture.

The fixture is connected to a length of double conductor, silk,

not less than 15 feet in length and finished off with a non-water-tight attachment plug. It is usually finished in bronze.

The Portable.—*The non-water-tight portable* is shown in Fig. 247.

A brass tube is inserted in a wooden handle. The outer end of a second tube is coned for a D-13 gasket and fitted with a gland. Around the inner end is a base ring, perforated with ten ½-inch lightening holes and secured to the first tube by two clamping rings set up against sheet-rubber packing rings, one ring packing the interval between the base ring and the tube. The end of the

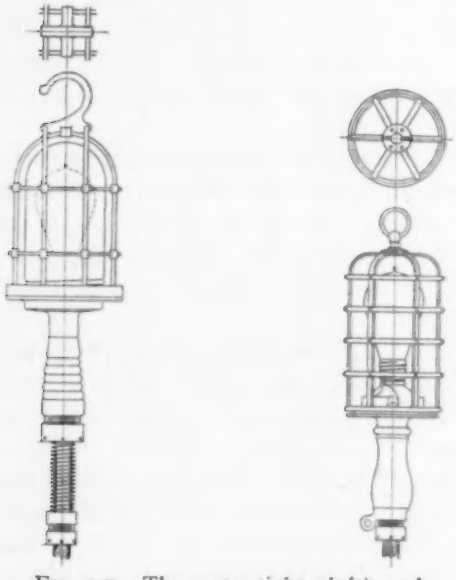


FIG. 247.—The water-tight (left) and non-water-tight portable.

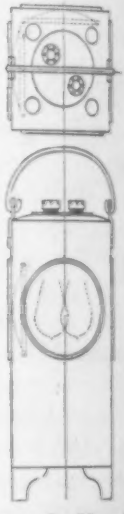


FIG. 248.—Magazine lantern.

first tube is threaded to take the standard metal socket. The guard is made of light flat brass wire with six guard rings riveted to the four upright flat wires. The top is finished off with a knob casting and ring to which the upright wires are riveted. The base of the guard is a cast ring to which the upright wires are also riveted, and which is threaded on the inside to take a similar thread on the flange of the base ring.

The portable is wired with double conductor, plain, wire; one-half the allowance to a ship has a 25-foot conductor, one-fourth a

50-foot and one-fourth a 100-foot. The attachment plug is of the water-tight type.

The portable is finished in dark bronze.

It is intended as a non-water-tight, light type for usual and convenient service about ship locations where it is not likely to meet with rough usage or dampness.

The water-tight portable (Fig. 247) is made up in the same general style as the steam-tight fixture, the construction answering for both except in the following parts.

Cast with a cross is a brass hok for hanging the portable. The base consists of a brass tube around which is worked a fluted wooden handle; the outer end of the brass tube being fitted with a gland which sets up on a D-13 gasket around the double conductor, plain, wire used for the fixture. Brazed to the outer end of the brass tube is a phosphor bronze spring ending in a brass casting which is fitted with a gland for a D-13 gasket; this is similar to, and for the same purpose as, that of the non-water-tight portable.

This portable is intended to be used in double bottoms, engine, and fire-rooms, damp locations, or where a portable is to be subjected to hard usage; and it is made water-tight. Being furnished with a glass globe and a heavy guard it is too heavy a fixture for ordinary use, and the lighter type before described is supplied for the ordinary occasions of portable use.

One-half the allowance is wired with a 25-foot conductor, one-fourth with a 50-foot, and one-fourth with a 100-foot, the water-tight attachment plug being used. The finish is in dark bronze.

Magazine Lantern.—The lantern is shown in Fig. 248, and consists of a rectangular sheet-brass case about 18 inches high, in the sides of which are four openings, without glass or lenses, about six inches in diameter. The whole is riveted and brazed together and at the top are riveted two lugs for a wire brail. The bottom is finished for four feet at the angles. In the center of the top is an aperture about 1¾ inches in diameter through which the lamps can be seen.

Stuffing tubes are brazed in near two of the corners of the top, taking D-13 gaskets with the ordinary gland; a standard socket is fitted to each stuffing tube and inclined so as to lie opposite the reflectors. Two reflectors are used, made of sheet brass and silver plated; to each is attached a hooked brass strap which can be

hooked into straps riveted over each of the side openings. The reflectors can thus be shifted in the lantern as desired. One lamp is to be lighted at a time, though sometimes, but rarely, both are used, depending on the construction of the light box.

The light box is a permanent, water-tight metal casing let down from the deck of the ship and in which is placed large circular glass lenses to admit light into the magazine or shell-room; the lantern is, therefore, designed to lift out or be lowered into place.

Two double conductor, plain, wires, about 18 inches long, are used, with water-tight attachment plugs which plug into the receptacles attached to the inside of the light box.

The lantern is finished in dark bronze.

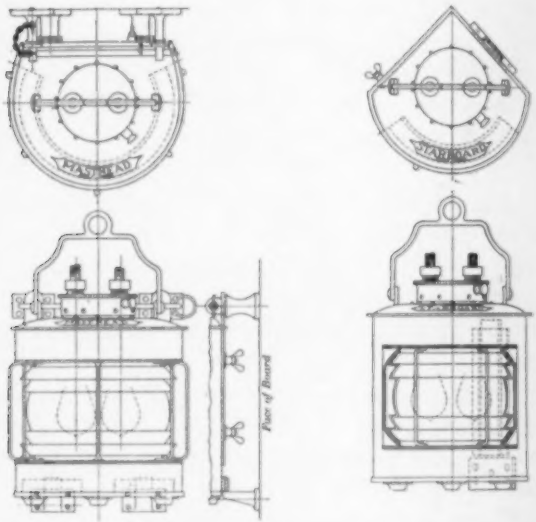


FIG. 249.—Masthead (left) and sidelight lantern.

Running Lights.

The running lights include a white masthead light, and a red and a green light for the two side lights. They are finished in dark bronze color.

Masthead Lights.—The masthead lantern is shown in Fig. 249. It consists of a base and a top made of No. 21 sheet brass, which are held together by five small stanchions, one in the center and two at each side, which also form the guards for the lenses. The top secures to a brass casting, in which are soldered two

stuffing tubes taking D-13 gaskets for packing the two double conductor, plain, wires leading to each of the two lamps with which the fixture is provided. Cast in one with the brass casting are two hollow masses which form the support for the lamps. The front of the base is perforated near the bottom with ventilating holes. To the brass casting on the top is riveted a movable bail for carrying the fixture, and in the center of the top of the bail is an eye to which a halliard may be bent. On the back of the fixture, at the top, are secured two lugs which fit over perforated lugs on the mast fitting; pins secured by chains hold the light in place on the mast. At the bottom of the back are two brass strips which fit over two hooks on the mast fitting and hold the bottom of the fixture.

The lenses are Fresnel (French), clear, cut-glass lenses five sections for each lens, a lens forming a quadrant; four sections are quadrants containing one prism each and the fifth section is a quadrant which is the central plano-convex lens. The lenses are cemented in a brass frame when purchased, a mid frame being used for two sets of lenses to obtain the 180 degree aperture of the light. Although the general shape of the masthead light exceeds a semi-circle, the lenses cover exactly 180 degrees of the circumference.

Inside of the lantern at the back, and extending for a short distance towards the side is a corrugated, silver-plated, polished reflector extending from the bottom to the top.

The hinged door for access to the lamp is on the back. Two wing, socket nuts on the door screw on two stud bolts soldered to the frame and secure the door when closed.

Two 32-candle-power lamps are always installed in this lantern, but it is not intended that more than one shall be used at a time; the second is ready to turn on in case of accident to the first.

The two double conductor, plain, wires are finished with watertight attachment plugs for attaching to the receptacles on the mast near the location of the light. The length of wire is governed by circumstances for the particular ship.

Top Light.—The top-light lantern is identically the same as the masthead lantern, except that it is marked "Top." It is installed on the after side of the after mast of flagships.

Towing Light.—This lantern is also identical in construction with the masthead lantern except that it is marked "Towing."

The arrangements for securing the lantern below that for the masthead lantern are identical with those installed for the latter.

Range Light.—When a range light is allowed a ship a masthead lantern is installed for the purpose.

Side Light.

The side light is shown in Fig. 249.

Its general construction is similar to that of the masthead light except that its frame is shaped at the back to fit the right-angled corners of the light boxes. The lens is identically the same as that used for each half of the lens aperture of the masthead light and is furnished cemented in a composition casing ready for securing to the frame of the light. Just inside of the lens is fitted a guide, at the top and bottom, in which is placed a curved glass shade of green or red glass, accordingly as the side light is to be the starboard or the port light. The hinged door is placed on one side of the back, winged locking nuts being fitted in the same manner as for the masthead light. The top and bottom are secured by two guards only. The casting at the top is similar in construction to that for the masthead light, except as to difference in shape, and of the same general dimensions.

Two 32-candle-power lamps are provided (one only to be used at a time), which are wired with double conductor, plain; the wire lengths are cut to suit the particular ship, and are finished with water-tight attachment plugs which plug into the receptacles on the bridge, or near the side light, if located elsewhere.

To secure the light in the light box a tongue of brass of rectangular section is secured to the after side of the light box; a wide brass strip riveted to the back of the frame of the light slips over this tongue and holds the light firmly in place.

A movable bail is attached to the fixture for transporting.

Signal Lanterns (White, Green, and Red).

The signal lantern is shown in Fig. 250.

It consists of a top and bottom of No. 21 B. & S. G. brass, which are secured together over the lens by the guard posts shown; in addition a guard ring is placed near the top and bottom, to which are attached wire rings through which halliards can be led to hoist and steady the lantern. The top is a casting having but one central stuffing tube for one double conductor, plain, wire

leading to a type-A socket, which is screwed underneath the top of the casting and cushioned by a ring of sheet-rubber packing. The length of the double conductor wire is governed by the requirements of the particular ship; the wire is terminated in a water-tight attachment plug.

The lens is cylindrical with a plano-convex center and prisms, shown, and is in one piece. It is the ordinary six-inch, commercial type lantern lens, and interchangeable with those used in the truck lights, etc. For the green and red lanterns, green or red

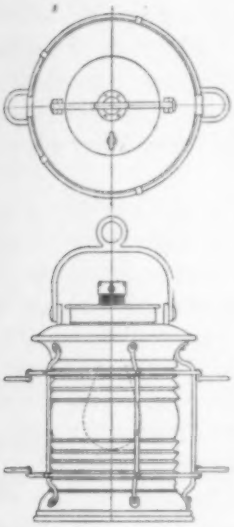


FIG. 250.—Signal lantern.

FIG. 251.—Diving lantern.

glass is flashed on the interior surface of the lens giving the color; the structure of the lens is of white glass. The usual allowance of signal lanterns to a ship is six white, three red, and two green.

Stay Light.—Formerly a stay light with 8-inch lens was prescribed, but the white signal lantern now serves the purpose. A 32-candle-power lamp is used in this lantern.

Stern Light.—The white signal lantern is used for the stern light, being set in a stern light fixture, so constructed that the light will show directly aft and about two points on each quarter.

Peak Light.—White signal lanterns are used for this service, securing to the halliards when hoisting on the flagstaff. More recent practice, when a gaff is available, is to make up a ladder to

which the lanterns can be suspended and connected up by a cable, the arrangement being left in place when the vessel is at anchor; this device is not usual for other than flagships.

Diving Lantern.

The diving lantern (Fig. 251) consists of a casting, to which a type-A socket for a 150-candle-power lamp is secured by two screws and cushioned by a ring of sheet-rubber packing. The top of the lantern is also a casting, fitted with an eye and ring, and is secured to the base by six rods which screw into the base casting and secure at the top by locking nuts. The globe is a cylinder of plain glass without lenses, and is set into two moulded rubber packing rings, which pack the fixture water-tight when the locking nuts are set up. To ensure a tight joint the lower edges of the globe are bevelled on each side.

To the base is screwed and brazed a tube carrying at its outer end a gland which sets up on a B-type gasket; the extension of the tube is a spring with casting and gland setting up on a B-type gasket. The office of this spring is to prevent a nip on the wire at the outer end of the tube, as for the water-tight portable. The conductor used is the especial type of double conductor, diving lantern, and is 100 feet in length; each wire of the conductor is connected to a 25-ampere water-tight attachment plug, which plugs into the two contacts of the 25-ampere receptacle.

The joints of the diving lantern are brazed after assembling so that the top or bottom appears to be a single piece instead of in parts. The finish may be a dark bronze, but the fixture is more often polished and lacquered.

The Double Truck-Light Fixture (Fig. 252).—A cast brass sleeve fits over a tenon on the top of mast to which it is held by eight bolts, if an iron mast, and four through-pins, if a wooden mast. Near its upper part are cast the cheeks for the sheaves for the signal halliards, and gussets upon which the base plate shoulders. The base-plate is a brass casting threaded on its collar to screw into the top of the sleeve casting. At one side of the base plate is a vertical flange to which is bolted a square copper lightning rod, 46 inches long; the lower end of the rod is drilled for soldering in a copper lightning conductor; the upper part of the rod is bent in to cover the fixture. The flange is so located on the

base ring that the plane of the lightning rod will set 45 degrees abaft the plane of the athwartship line, and on the port side.

The base plate is drilled for four flathead, countersunk bolts which secure the urn-shaped section which forms the base of the fixture proper. Two large hand holes are cut in this section for access to the gland, lamp, etc., of the lower (white) half of the lantern.

The upper part of the urn-shaped section is flanged for the four posts which support the cover of the lantern which secures the lenses. The inner side of the flange is threaded for the base ring; when the base ring is screwed in place the joint is soldered.

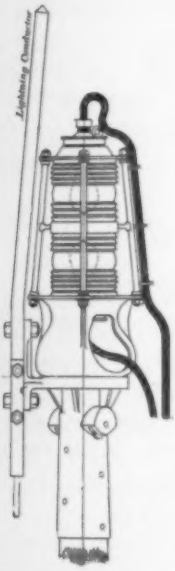


FIG. 252.—Truck-light fixture.

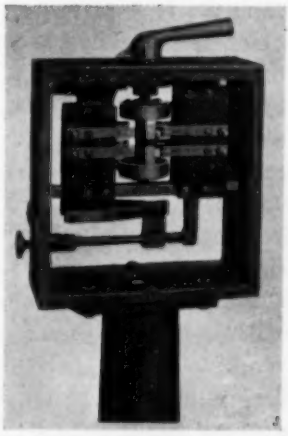


FIG. 253.—Truck-light controller.

The lantern base, coned for a D-13 gasket, is held to the base ring by a cap ring; the joint at the base ring being packed water-tight by a sheet-rubber packing which also forms a cushion for the type-A socket. A similar arrangement exists in the construction for the lamp and socket, in the upper half of the lamp except that the base ring is a part of the cover casting.

The cover piece is drilled to correspond with the holes for four shouldered posts, which have threaded stud ends to take the nuts. A ring acts as a blank flange, or diaphragm, between the upper

(red) half of the lantern and the lower (white) half; this ring has arms with flanges, the flanges being soldered to the posts. Riveted to that post which is diametrically opposite from the lightning rod are three rings, through which is rove, and to which is seized, the length of double conductor, plain, lightning wire which feeds the upper lamp; to prevent a nip at the upper gland the conductor is seized to a cast gland.

The lenses are fitted in between the diaphragm and the base or the top, and are set tight in cement by the nuts of the posts; these are ordinary commercial, six-inch, pressed-glass Fresnel lenses; the upper lens is red, the red color being imparted in manufacture by flashing red glass on the interior surface of the ordinary white lens.

The many parts of the fixture are to afford convenience in replacing lenses, sockets, and lamps aloft. Once installed the sleeve and the base plate become an integral part of the mast as the fixture proper above it can be sent down by unscrewing the nuts.

Lamps of 32-candle-power are always used in the lantern of this fixture.

Truck-Light Controller.—The double truck-light controller, for two masts, is shown in Fig. 253; a modified construction is installed on single-masted ships.

It consists of a composition casting open on the back and front; the openings being made water-tight by back and front plates and sheet-rubber gaskets. Each plate is secured to the casting by eight machine screws. The casting is usually secured to a hollow pedestal of the same metal, which is fitted with a hard rubber tube through which the wires are led to and from the controller. On the top of the casting is a boss through which is passed a spindle having on its upper end a lever and pointer, cast in one piece with it, and recessed to fit over the boss to prevent water from entering the casting. The lower end of the spindle is steadied in a hole drilled in the lower cross bar of the casting. The lever and pointer may be moved to any one of six positions as indicated by the words, "Red, Off, and White" for the fore, and "Red, Off, White" for the main truck lights, respectively, on the right and left of the top of the casting. The pointer is retained in any of the above positions by means of a plunger and spring which engages the notches on a cam secured to the spindle.

The switch barrel fits on the spindle and is kept in place by a set screw. Secured respectively to the top and bottom, and insulated from the switch barrel, are two switch contact rings. Secured vertically to the inner part of the casting are four micanite contact spring insulators, to which, in turn, are secured the phosphor bronze contact springs and wire terminals.

Facing the front of the controller, the lower left hand contact spring in front of the casting connects to one of the line wires and has the pulsator in circuit. The other side of the line connects to the right hand upper spring at the back of the casting. The leads for the red light on the mainmast connect to the upper left hand contact springs, and those for the white light on the mainmast to the contact springs on the right hand side of the front of the casting. The circuits for the red and white lights on the foremast connect to the contact springs in the back of the casting directly opposite those for the mainmast.

The pulsator consists of a knob, spindle, washer, collar, contact carrier, and spring. The knob is secured to the end of the spindle which projects through the left side of the casting, and the other end of the shaft is seated in the projection on the inside of the casting. The washer of the spindle serves as a gasket to prevent moisture from entering the casting. The collar controls the outward thrust movement caused by the spring. The contact carrier of the spindle, normally in contact with the lower contact springs, maintains the continuity of the lower line wire until the pulsator knob is pushed in, which action disengages the contact carrier from the contact springs and opens the circuit.

The operation of the controller is as follows: Moving the pointer, say, to the red for the foremast, the line wires being in contact with the switch contact ring permanently (unless the pulsator is operated), the current passes through the projection on one side of the switch contact rings, through one of the springs marked F-R (Fore Red), through the lamp in the upper half of the lantern, and back through the other spring marked F-R (Fore Red) to the projection on the other switch contact ring and the other line wire. When the pointer is moved to "Off" the projections on the switch contact rings are thrown clear of the springs thus opening the lamp circuit.

The truck light on the fore has two purposes: one is for use for signalling; the other is in case of any defects in the truck light on

the main, that it can be substituted for it. The same rules apply to its use under these circumstances as have been stated for the main.

When connecting the wires on the controller the following rules must be observed: The terminals attached to the contact springs have a small hole drilled in them into which the wire leads must be soldered. The line wires connect to the terminals of the contact springs which are marked "L" (Line), and the leads for the upper half of the lantern (red) on the foremast connect to the terminals of the springs marked F-R (Fore Red); the leads for the other half of the lantern to the springs marked F-W (Fore White). The leads for the lights on the mainmast are connected similarly, the white connecting the springs marked M-W (Main White) and the red to those marked M-R (Main Red).

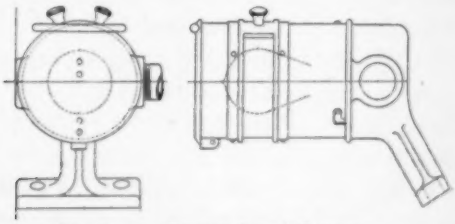


FIG. 254.—Turret-hood fixture.

The back and front covers of the controller case should be removed at least once every two months, and the contacts which have become discolored or corroded should be replaced or repolished, and any irregular or burnt places should be smoothed by emery cloth *but not filed.*

The plunger and spindle require occasional oiling.

The Turret-Hood Fixture (Fig. 254).—It consists of a sheet-brass barrel attached by screws to a casting. The flange of the casting arm is secured at the top of and back of the sight hole in the turret hood. The casting forms the base for a socket for a 5-candle-power lamp which throws its light through the end of the fixture into the sight hole. This enables the officer to see the cross-wires of the telescopic sight. The end of the barrel can be closed by a door.

In the side of the barrel is a small port through which light can be thrown down on the graduations on the drum of the telescopic sight; a slip ring closes and opens this port.

Telegraph Fixture.—The fixture, shown in Fig. 255, is intended to replace the oil lamp which lights up the dial of a mechanical engine-room telegraph. There are two types for the varieties and size of telegraphs. The fixture consists of a cylinder in the top of which is secured the socket for a 5-candle-power lamp.

The stuffing tube at the side takes a double conductor, plain, wire with D-13 gasket; the conductor is finished off with a watertight attachment plug and is long enough to reach a hooded receptacle which is installed on the pedestal of the engine telegraph.

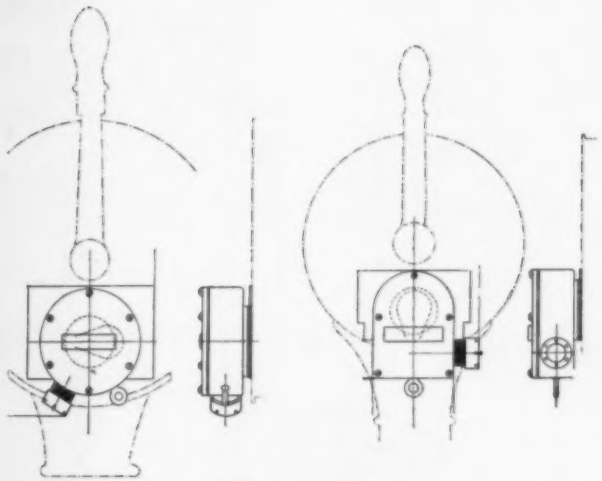


FIG. 255.—Types of telegraph fixture.

The cylinder is attached to a rectangular plate of brass, perforated in the center for the diameter of the cylinder for the passage of light, the opening being covered by a thin sheet of mica; this plate fits in the guides on the back of the telegraph which were intended for the oil lamp; the oil lamp, or telegraph light, can, therefore, be used at will. The fixture is finished in dark bronze.

Binnacle Lights.

The type for ships' binnacles (Type VI) Fig. 256, left, consists of a cylindrical attachment fitting through the binnacle cover (dotted lines). A type-A socket is fitted inside holding a 16-

candle-power lamp which shines vertically down through an orifice in the bottom of the device and directly upon the face of the compass. The device is removable by a bail at the top. For oil lighting a separate top is provided, that carrying the electric lamp being removed; this top is fitted with a reflector and the oil pot is set off center.

The type for torpedo-boats (Fig. 256, right) differs in being designed to be inserted in the side of the binnacle cover. No oil arrangement is necessary as a separate lamp can be used in case of failure of electric energy.

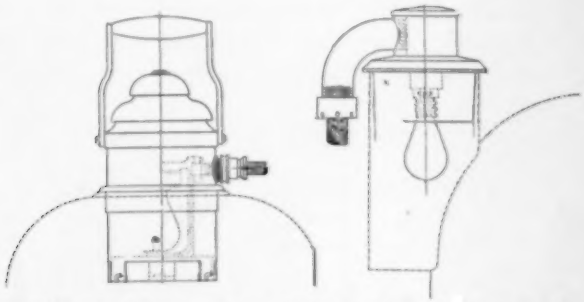


FIG. 256.—Binnacle light for ships (left) and torpedo-boats and destroyers.

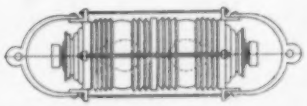


FIG. 257.—Lantern for night-signal set.

Lantern for Night Signalling Set.

The type shown in Fig. 257 is that now used for the purpose (see also Fig. 269). It is made of composition or bronze, usually finished in a bronze color and consists essentially of bottom and top castings containing the stuffing tubes for the circuit wires, the top and bottom pieces being held together by four side rods.

The lenses are 6-inch and are cemented to the top and bottom pieces and to a separating diaphragm; the upper lens is red, the bottom lens white.

Type-A sockets are used and so disposed that the upper lamp will drop and the lower lamp will stand vertically.

Fixtures and Lanterns for Torpedo-boats.

Masthead Lantern.—The type (Fig. 258, upper left) is a modification of that for ships, and is fitted to be used with oil also, the upper closing cap being removable and can be replaced by a ventilating chimney. As mineral oil is ordinarily burned, a glass chimney for the burner is necessary. The lens is 4½ inches.

Side Light Lantern.

This is constructed (Fig. 258) for use with both electric and oil light. As no light boxes are installed on the boats, the lantern is fitted with a screen whose angles are such as to conform to the law that the light shall show from directly ahead to two points abaft the beam, but not across the bow. The lens is 4½ inches.

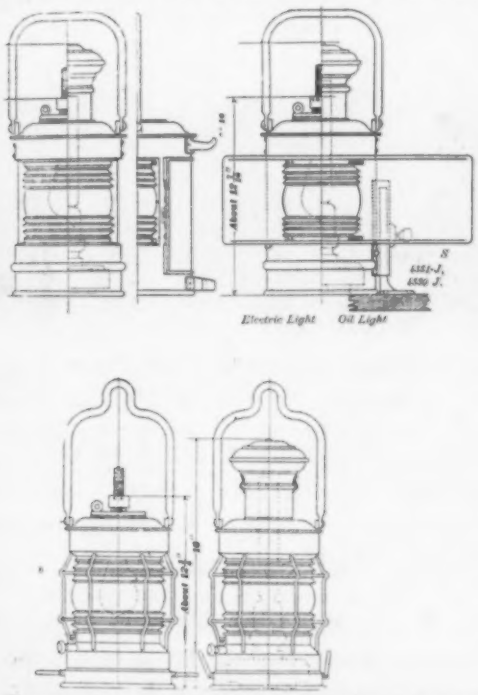


FIG. 258.—Torpedo-boat running lights and signal lantern.

Signal Lantern.

In this design a removable cap for the electrically lighted (Fig. 258, lower left) can be replaced by a ventilator (Fig. 258, lower

right) following the general method pursued in the masthead lantern.

The lenses are red, green, and white, with color blown on, and of the same size as those of the masthead.

Truck Light.

In its best form this fixture is simply a reduced dimension of that for larger vessels, the reduction being made to conform to the same size lenses as are used with the torpedo-boat masthead lantern, 4½-inch. But one is installed on each boat and only a single controller is placed.

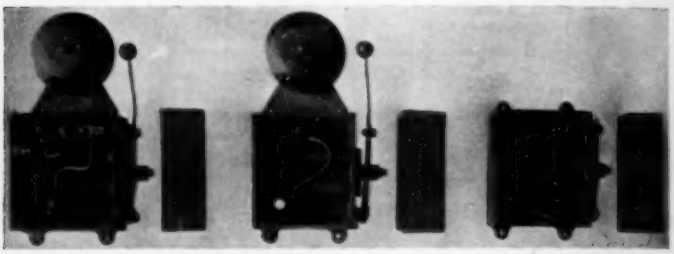


FIG. 259.—Water-tight vibrating bell (left); water-tight single stroke bell (center) and buzzer.

Night Signal Set, Two Light.

A single night signal lantern, reduced in dimensions to conform to the 4½-inch lens, is located on the forward side of the mast. Signals are made by wigwag, 1-2 code.

Magazine Light Fixture.

The general construction of this fixture is modelled after that of the overhead bunker fixture which it closely resembles, though smaller in dimensions.

CHAPTER XIV.

INTERIOR AND EXTERIOR COMMUNICATION.

Call Bells.

Under this signification is included all such material as is used for simple methods of calling attention to the point of origin of call, by bell, or buzzer, and by annunciator indication.

Bells.

There are two classes of bells, water-tight and non-water-tight, and each class is of two kinds, vibrating bells and single stroke bells.

Water-tight Vibrating Bells.—There are two sizes, 6-inch and 3-inch, differing only in the size of the gong.

Fig. 259 shows the 3-inch size having the usual vibrating arrangement (as explained in bell circuit below) for the bell and also a compartment containing the vibrator and contacts, the mechanism and contacts being water-tighted by a cover and packing, as in the case of water-tight wiring appliances. The circuit wires are brought through a stuffing tube in the back. All mounting insulating material, including magnet heads, should be hard rubber.

Non-water-tight Bells.—There are two sizes, 5-inch and 2½-inch, corresponding to the usual commercial types. The cover is a box which fits over the mechanism, hooking by a lug in a recess on the gong side to give a kind of hinge effect and securing on the opposite side by a snap spring, the spring and lug to be sufficient to insure that the cover will not fall off under gun-shock or mechanical shock or jar.

The mechanism is similar to that for the water-tight bells, omitting the features essential to the water-tight construction.

Water-tight Single-stroke Bells (Fig. 259).—The essential difference between vibrating and single-stroke bells is that when the circuit is closed for the latter, a single stroke only is made on the gong instead of the vibratory, successive strokes for the former; single-stroke bells, therefore, require a spring attach-

ment for their armatures, but no interrupting contact. The pattern and mechanism, omitting this feature, is the same as that of the vibrating bell. All water-tight, single-stroke bells have 6-inch gongs; they are used in water-tight compartments, and generally as signals for the departure of boats.

Non-water-tight, Single-stroke Bells.—These have the same general construction as the non-water-tight vibrating bells omitting the interrupting contact.

Buzzers (Fig. 259).

There are two classes, water-tight and non-water-tight.

Their construction is similar to that of the vibrating bells, but, instead of a gong, the clapper or armature strikes against the

FIG. 260.—3-drop water-tight annunciator.

magnet cores. They are used mainly in connection with annunciators, but are sometimes used when the noise of a bell would be too great, or where it is desirable to distinguish from a bell call in the same compartment or location.

Other types of bells are installed than those shown in Fig. 259, and differing in details of construction.

Annunciators.

This apparatus affords a convenient method of grouping a number of calls at one location, the apparatus indicating the station from which the call originated and at the same time a bell or buzzer, in series with and in common for all the drops, sounds and calls attention.

Fig. 260 shows a three-drop water-tight annunciator with the

mechanism heretofore in use; there are at least three types of drop in use. The particular style shown is that classed as the gravity shutter drop as distinct from the needle drop in whose mechanism arrangement is made to move a needle to an indication marked on the face of the dial.

The drop is an electromagnet circuit which when magnetized attracts armatures fitted with the notches which hold the shutter in its normal position; the shutter then falls and exposes the indication through a square hole in the instrument face, the bell or buzzer sounding at the same time. A bent rod (shown) can be pushed up by the push handle and restore the shutter in the catch of the clutch. In present designs the push is made flush with the case and covered water-tight by pigskin or lace leather as in the water-tight push button; the case is also made more securely water-tight by securing with flathead screws instead of wing nuts.

For the non-water-tight annunciator the case is made of mahogany with a hinged face and the drops are attached to the case.

Water-tight annunciators often contain a large number of drops (as for fire alarms and magazine alarms), but the non-water-tight types rarely exceed 24 total. The arrangement of the indications is for so many "high" and so many "wide," as may best suit the position in which they may be installed; for instance, a 24-drop annunciator may be either 4 high and 6 wide, or 6 high and 4 wide.

Primary Batteries.

The installation of primary batteries is usually inadvisable; they polarize and lose voltage from even slight grounds on the lines; the room for battery lockers is generally difficult to set apart. The advantages of transformers is discussed under those machines.

Cells.—The liquid cell in general use is the form of Leclanche known as the Gonda. There are other types of merit, but the supply is mainly confined to the Gonda in order to avoid many types of spare parts. The negative element (positive pole) is a carbon plate with conglomerate blocks attached without the porous cup; the positive element (negative pole) is a zinc rod. The liquid used is a solution of sal ammoniac, 5 ounces of the salt per cell.

Polarizaton of this cell is indicated by a milky appearance of the liquid.

The zincs last longer if amalgamated by first cleaning and then dipping in mercury until uniformly coated.

For torpedo-boats and destroyers the type of primary battery is one of the many forms of dry cell. Dry cells cannot be restored when once run down and must be replaced.

Telegraphs and Indicators.

In many of this type of apparatus the visual method of reading the signal is employed, the indicator containing small lamps which

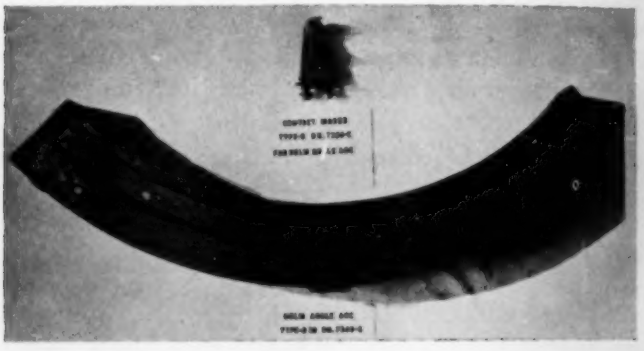


FIG. 261.—Parts of contact for operating helm angle indicator system.

illuminate legends on discs, the lamps being set in compartments to illuminate a single disc only. Of these "lamp-indicating" devices the helm angle indicator was the original and its method of lamp installation is pursued in the others.

Helm Angle Indicator.

The object of the helm angle indicator is to show at all times the relative position of the tiller to the keel of the ship. The system consists essentially of a contact arc, a contact maker, and an indicator, with the necessary wire connections.

The helm is provided with a contact as shown in the upper part of Fig. 261, consisting of a cast bracket which is bolted to a fitting piece attached to the rudder head; insulating bushes and plates prevent it from grounding.

In two vertical holes are fitted hollow plungers in which carbon

cylinders are secured by clamping screws and shoes; these carbons make moving contact with the continuous and divided arcs. Spiral springs, pressing between the top surface of the bracket and shoulders cast on the plungers, maintain the carbons in contact.

Earlier patterns of this apparatus had only the divided arc and a single plunger contact. This construction required a flexible connection to the contact which involved the likelihood of being jammed in the moving parts.

Two brass arcs are contained in the contact box (Fig. 261) one arc being divided into 15 contact sections, insulated from each other, and the other arc being continuous. The contact box is made in the form of a segment of a circle, and is open on its lower

FIG. 262.—Indicator for helm angle.

surface to permit the contact maker to travel along the surface of the arcs. The box is closed on the upper surface by a cast iron cover made in two sections and secured to the box by tap screws; rubber gaskets under the plates water-tight the box from above.

Each of the 15 contact sections is connected by wire to one lamp in the indicator (Fig. 262), and which is cut to indicate seven angles of the helm, starboard and port.

The contact sections correspond to the different angles of the helm, and are of such widths that the insulated separations are half way between all indicated angles. The center section is designated zero, and corresponds with the position of the tiller when it is parallel to the keel of the ship. These contact sections are secured to a mahogany insulated block, made in three thicknesses and glued together with the grains crossed. The block is faced with micanite, is secured to the casting along its entire length with

machine screws, and is made water-tight to the casting by a rubber gasket. The manner of securing the section is, in the case of the small ones, by machine screws passing through the mahogany block and securing into the brass terminal block, furnished with a sheet copper terminal into which its respective wire is soldered. In the case of the larger section one or more metal blocks are used to secure the section in addition to the terminal block.

One side of the line, used for the common return wire for the whole system, is connected with the continuous brass arc shown; the other side of the line is connected to the plate containing the contact sections. The contact maker operates between these plates.

The indicator (Fig. 262) consists of 15 instrument lamp sockets for fifteen 5-candle-power instrument lamps, all contained in a circular brass casting which can be opened in front, being closed by a cover which is secured to the casting by screws. The figures conform to the nearest angle of the helm, but by an arrangement of the contact sections *the break is made half way between each indication,* that is, one indication is still on until the tiller has reached the position half-way between that indication and the next, when the next indication is switched on across the insulation.

The figures on the left half of the cover are backed with red glass cemented to the cover which, when the instrument is working, show when the tiller is to port. The figures on the right half of the cover are backed with green glass and show when the tiller is to starboard. The zero marking is backed with white glass and shows when the tiller is amidships.

The sockets with lamps are arranged in an incomplete circle and secured in the case, each lamp being behind its respective figure and separated from the adjacent lamp by a wall of sheet brass which prevents the illumination of any other figure than the one indicated by transmission of light from one lamp compartment to the other.

The indicator is commonly secured to a hollow brass pedestal, through which the 16-wire cable is run. One of the wires in the cable is the common return and is connected to one terminal of each lamp socket; the other terminal of the lamp socket is connected, respectively, to one of the remaining 15 section wires. The other end of the cable enters the contact box, and each wire connects to the terminal block of its respective section; for instance,

the wire from indication 2½, port, on the indicator, connects to the first section of the transmitter arc on the port side of the zero; and for 2½, starboard, on the indicator, a wire connects to the first block on the starboard side of the zero section, and so on. The common return wire secures to the continuous arc.

The operation of the system is as follows: The current is switched on, and the controller being moved to, say, 10 degrees starboard, the circuit will be from the line, through the contact maker, to the section on the arc corresponding to 10 degrees starboard, through the section wire to the lamp in the rear of Figure 10, starboard, on the indicator, and then by the common return wire to the other side of the line, through the continuous arc of the box.

When the system is not in use the plungers should be slipped into the slots on the tubes of the contact maker, and should be let down on the arc before switching on the current. When the system is to be used, *the plungers should be eased out of the slot,* otherwise the carbon point is liable to be broken by striking the arc too violently. The contact plate should be kept clean and all connections kept tight to ensure good results. The only repairs to which the system is liable are wearing or breaking of the carbon contact point or breaking or burning out of lamps. The system is simple, and, with ordinary care, is not liable to get out of order. As many indicators as may be desired may be installed on the same circuits by paralleling across the cable leads through the connection box.

Steering Telegraph.

The transmitter of this apparatus is similar to that shown in Fig. 263. Its indications are cut for the angles of helm corresponding to those of the helm angle indicator with the addition of a "steady" order.

The transmitter includes its own indicator, as described for the engine telegraph, and consists of a pedestal with a cylindrical case, the latter containing the mechanism for ringing a magneto bell at indicator stations, and for causing an electric light to burn behind the figure on dial of the station indicator.

On the spindle of the operating handle is a metal wheel geared to fit a sprocket chain; this chain leads down into the pedestal to the multiplying gear, and thence another sprocket chain leads to

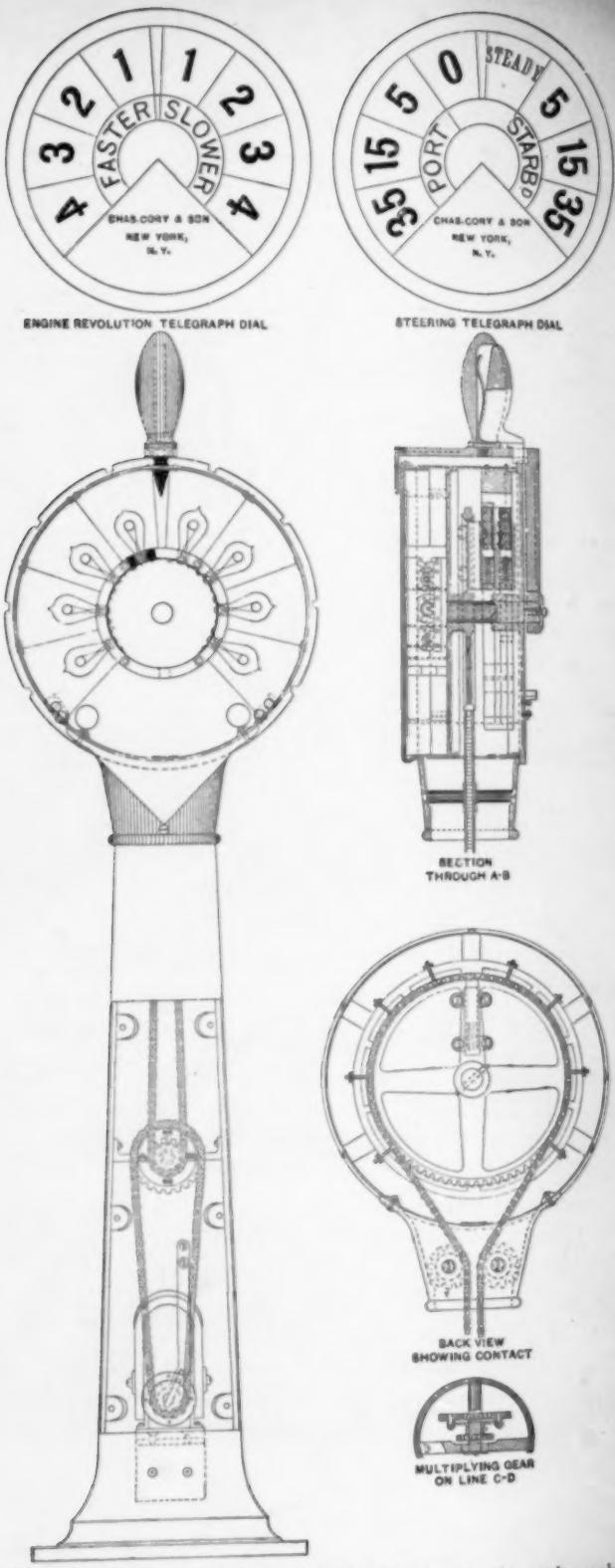


FIG. 263—Engine telegraph (dials include steering telegraph).

the armature of a magneto generator, secured in the pedestal. Wires are led from the brushes of the magneto to the magneto bell in the steering engine-room or to steering wheels.

Secured to the sprocket wheel of the transmitter, on the rear side, is the contact maker, insulated from the wheel and constructed on the same general plan as for the engine telegraph. The current paths are alike in each telegraph. No reply is required as the helm angle indicator shows the action taken by the helm.

A metal plate divides the transmitter into two parts, that part in front forming the indicator. The indicator is of the same general construction as that for the helm angle indicator, the face being cut for orders identical with those on the transmitter shown in Fig. 263.

A water-tight magneto bell is installed near each indicator at the steering stations.

To give an order by the steering telegraph it is necessary to move the handle over the entire arc of the face to give ample alarm in the ringing of the magneto bell. The pointer of the lever should be left in the center of the division containing the required order, and the clutch should drop into the notch; an alternating current will be generated by the magneto, ringing the bell at the steering stations; contact will then be made on the lamp circuit, lighting the lamps behind the required order on each indicator.

To farther assure the orders at night when the words "starboard" and "port" may not be distinguished, the port indications show through a red glass, the starboard through green glass; the "O" and "Steady" show white.

The different station indicators are connected up in parallel on the same transmitter circuit.

Engine Telegraph.

The difficulty of obtaining a direct-reading device which will certainly indicate, over practical periods, the number of revolutions at which it is desired that the engine shall drive has occasioned the adoption of the plan of establishing a standard number of revolutions for the standard speed and regulating the speed by indicating so many turns faster or slower, up to four turns in the standard telegraph. This range appears small for engines making averages of about 8 to 10 revolutions per knot, but can only be

altered for the especial cases by increasing the size of the telegraph. The design is not installed in small conning towers.

The design of transmitter (Fig. 263) is similar to, and a modification of, the steering telegraph in so far as the method of indicating is concerned. There is no method of reply for some of the types. In later constructions the indicator is of similar construction to the transmitter and a reply back is obtained by setting the transmitter, after ringing up, to the indication desired; this gives indications both in the transmitter and in the indicator. The transmitter lever is then put back to the off point and the indicator lever is put to the indication received; this gives indications at both ends as a reply back similarly to the original transmission of the order.

The transmitter includes its own indicator in order that the signal made may be checked at night, when the pointer would not be visible; the indicator, consisting of a set of lamp indications spaced and marked similarly to those of the telegraph, corresponding indications show the same in both for the same signal. The form of the transmitter, its operating handle and clutch, resembles the mechanical engine-room telegraph, and which it duplicates.

The indicator (Fig. 263) consists of a set of eight 5-candle-power lamps, whose sockets are mounted on a vulcanized rubber base behind the face of the dial. The dial is a brass plate with the numbers 1, 2, 3, and 4, cut through on each side of a vertical line. A white glass is behind the numbers on the side marked "faster" and a red glass behind the numbers on the side marked "slower." The telegraphs are generally mounted with the faster side forward and slower side aft.

The sockets for the lamps are fitted to the hard rubber base and the connections to the wires are made in the center. Each lamp is connected to the common return and to that section wire which connects with the corresponding metal strip in the transmitter.

Each lamp is in a separate compartment, so that it can illuminate only one of the perforated numbers. Strips of sheet brass are fitted between the lamps.

The indicator in the engine room is similar to the indicator in the transmitter in all respects, except that it is mounted on a bracket instead of on a pedestal; the water-tight magneto bell is installed near the engine-room indicator.

To give an order by the telegraph, move the handle over the

entire arc of the face to give ample alarm by the ringing of the magneto bell. The pointer of the lever should be left in the center of the division showing the required order, and the clutch should drop into the notch. An alternating current will be generated by the magneto, ringing the bell in the engine room; contact will then be made on the lamp circuit, lighting the lamp behind the required order on each indicator.

"Battle Order" and "Battery Control."

Telegraphs and Indicators.

The systems included under these designations, though still installed in a number of vessels, are probably to be superseded by entirely different designs and not yet approved.

FIG. 264.—Cory engine revolution indicator.

Engine Revolution Indicator.

This device is for the purpose of indicating at the bridge the number of revolutions which each shaft is actually making. The usual type is the Cory device.

Cory Type.—The objection to the Cory type of instrument is that it is not direct reading; it has the important advantages that its construction is simple, it will operate for long periods without getting out of order, and it is reliable; when it fails, the occasion is usually from corrosion or burning out of the contacts of the transmitter at the shaft.

Fig. 264 shows the indicator for one shaft which is mounted on the bridge and in the conning tower, and Fig. 265 the connections and essentials of the circuit.

A cogged eccentric is attached to the shaft and revolves with it. A cogged wheel gears into this eccentric and has an upright,

carrying a lever arm which makes contact with springs; this combination can swing about a center at, and in each revolution the cogged wheel is dragged enough in the direction of rotation of the shaft to make contact at the springs accordingly as the engine is going ahead or astern, and always on the same spring for the same direction of revolution. At each of the springs are connections to two electromganets in the indicator; but three wires being necessary as one wire answers as a common return for both. An armature connected to the pointer of the dial is at-

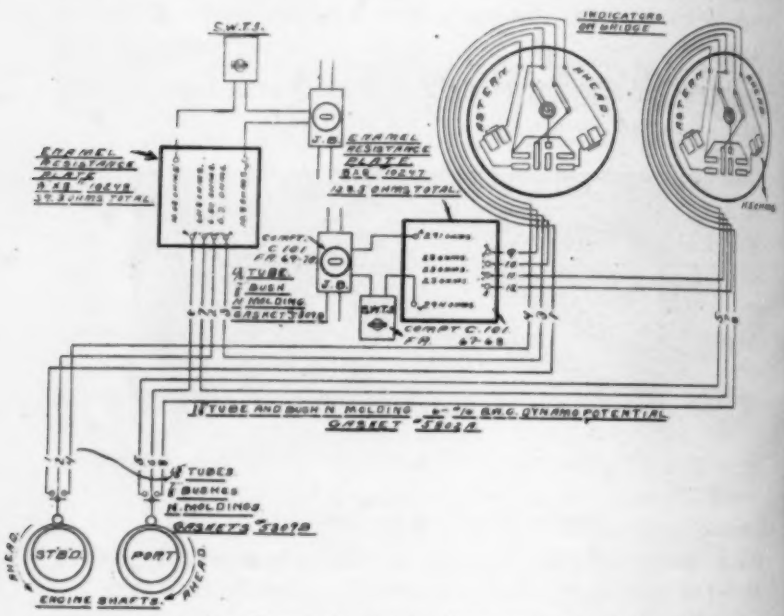


FIG. 265.—Connection details Cory revolution indicator.

tracted by the magnet, which is energized, and is arranged with a sounder to give an audible "tick" at each attraction (each revolution).

The contact lever arm and the springs are enclosed in a box. The assemblage is made on an oblong piece of slate on which a flat brass spring, mounted on a terminal block, is secured at each of the upper corners, these two springs are the electrical contacts for "Ahead" and "Astern." The wire from the corresponding magnet in the indicator connects to each of these terminals. Near the middle of the slate a lever arm is pivoted, and is slotted to

work on a pin and permit of an up and down throw; the upper end of the lever is fitted with a lead counterbalance weight, the lower end is forked and embraces the gear wheel, the gear wheel being insulated from the fork by a hard rubber bushing. The fork carries a holder on each arm and each holder has a hard rubber insulator, which, by means of a spring, presses against the gear wheel and keeps the latter from contact with the fork and prevents grounding of the electrical circuit at that point. A wire for current supply from a battery or transformer circuit connects to a binding post on the right of the slate, the binding post being connected directly to the lever arm; the lever arm is electrically insulated from all other parts of the mechanism.

The shaft-eccentric-ring is of composition, and made in two halves for facility of assembling on, or removal from, the shaft. One part of the periphery is plain and drilled to bolt to the engine shaft, the other part is eccentric and cut with teeth to engage the gear wheel.

The contacts should be kept clean and all connections tight; parts requiring lubrication should be occasionally oiled. The requirement of operation is that there should be sufficient current in the line to energize the magnets of the indicator; it is independent of variable resistances in connections, provided that the requisite energy is supplied.

Fire Alarms.

Magazine Alarms.

The apparatus for these services consists of thermostats so located as to give automatic intelligence of a rise of temperature above a designed maxima. Several types depending upon the expansion of mercury and melting of easily fusible alloys have been used, but are found to be inefficient. In mercurial types the oxidization of the surface of the mercury causes unreliable contact. The present types depend on the uncoiling of a spring; these types are really two, a water-tight type for coal bunkers and a non-water-tight type for magazines. Each of the two types has two varieties (A and B for fire alarms, C and D for magazine alarms) differing as explained below.

The type-A thermostat for coal bunkers consists of a composition box, with cover, and lugs for securing to the bulkhead or

deck, within which is secured the interior fitting shown in Fig. 266.

The type-A interior fitting consists of a coiled spring made of two metallic ribbons brazed together, one brass and the other steel (known as a thermostatic bar), and afterwards surfaced with a protecting coating of tin. The lower end of the spring is screwed to a lug on the base of a spindle which runs up through the center of the spring and ends in a casting; this casting being so shaped as to be secured by screws to the containing plate over mica insulation and to extend up to take the wire contact as shown on the left. The top of the spring is free and has secured to it a brass contact lever, about one inch and a half long, pivoted over a pin to restrict the motion to the circular as near as may be and give a firm contact. The outer wire contact, shown on the right is a casting, also secured over insulation, through whose end travels the set screw shown, and having a screw contact for securing the wire.

When the spring is heated it twists, and the bent contact tends to revolve and touch the set screw, thus making electrical connection in the circuit. The distance the set screw is set through its holder determines the necessary motion of the bent contact to bring it into contact with the set screw, and as this is dependent upon the expansion of the spring, and upon the temperature, the apparatus can be set by trial for the temperature desired—200 degrees Fahrenheit in this instance. The set screw has a capstan head for facility in making adjustments and a screw locks it in the position determined.

The type-B interior fitting differs from the type-A in having two extra contact lugs on each side, admitting of connecting in four other thermostats of the type-A style through its box. The type-B is thus a combined thermostat and connection box, while the type-A is intended only as the terminal of a run. The difference in use is: In a large compartment requiring a number of thermostats in different places, the supply cable is branched from a connection box into a type-B thermostat from which the other thermostats in the compartment (five are not unusual in one compartment) are connected in series, the system for the compartment being on one line to the annunciator. For the other thermostats in the compartment the type-A would be used except as necessary for the type-B connections; if but one thermostat is

installed in the compartment a type-A is installed. The boxes for the two types differ in shape and size.

The type-C thermostat, for magazines, is essentially the same as the type-A, though differing somewhat in features of construction and in being smaller. The differences between the C and D types are similar to those for the A and B, and for similar reasons; there is also a difference in the spindle details at the bottom connection.

The main difference in construction between the bunker and magazine types is in the direct exposure of the magazine type of thermostatic coil to the air and that protection from mechanical injury and overhead drip, etc., only are afforded. This is necessary by reason of the more rapid inflammability of the contents

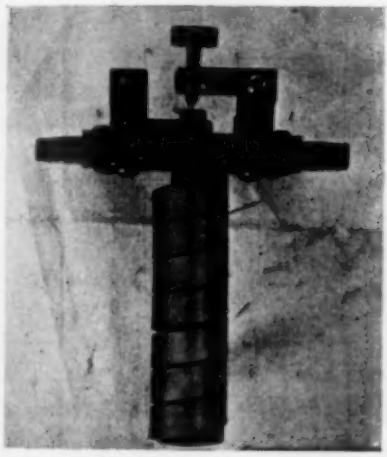


FIG. 266.—Interior fitting of thermostats.

of storerooms and the necessity for more delicate indications of a change of temperature in magazines. In bunkers the usual cause of ignition is due to slow spontaneous combustion and the feature of rapid indication has been sacrificed in favor of water-tightness. The practice of locating the type-A thermostats low down on bulkheads and embedded in coal, renders the water-tight features especially desirable.

In recent types superseding the C and D, the interior fitting is wholly enclosed so that inflammable gases within the magazine are excluded from access to the spark of contact.

Warning Signal.

This apparatus, sometimes called a shrieking whistle, was originally intended as an adjunct to the syren warning to close watertight doors or for collision, and to be located in those compartments whose occupants cannot hear the syren. While the original intention still obtains in some cases, the standard and more common use of the apparatus is as an adjunct to the general alarm gongs, the difference in installation being that the warning signal is installed in conveniently located positions below the protective deck only, and the general alarm gong in spaces above that deck; this division appears to be the most efficient and economical.

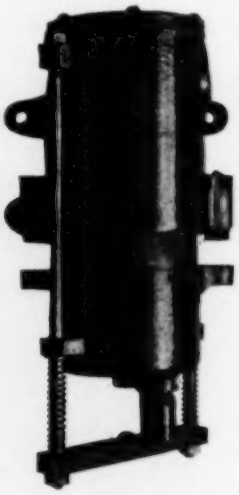


FIG. 267.—Warning signal.

A circuit closer for operating the system is located on the bridge (none are usually installed in conning towers). It consists of a brass base with a rectangular cover, packed water-tight by a cloth-insertion sheet-rubber packing. Upon the base is mounted a clock-work mechanism (similar to that of the electro-mechanical general alarm gong) controlled by a lever on the outside of the cover. A heavy coil spring actuates the mechanism and is secured to a control spindle to which the lever is attached. On the drum of the spring is a gear wheel meshing into a small pinion on the spindle of a five-pointed star wheel carrying anti-friction rollers in the ends of the star points. The uncoiling of

the main spring, which has been compressed by manipulating the lever on the outside of the case, causes the star wheel to revolve clockwise. A chain of gears down to the contact escapement controls the speed of the unwinding of this spring. On the inside of the water tight case and secured to the framework of the mechanism is an arm, pivoted at its extreme left-hand end, and carrying at the other end the contact for making and breaking the circuit. On the lower side of this arm is a V-shaped lug, resting normally between two of the points of the star wheel. When the star wheel revolves, the lug is lifted by the roller of each point of the wheel until the roller passes the angle of the lug when the lever drops back by its own weight. On the right hand end of the contact lever are two carbons insulated from the arm, and furnished with adjusting screws. These carbons make contact, when the lever is raised, with two carbons carried on the case and to each of which the line wires are connected, thus making the circuit. A double contact is made on the contact maker, the first by the carbons on the base, the second by metallic contacts on the lever and base, adjacent to the carbons, but making contact after the carbons have touched each other. The dimensions of the carbons are ⅜ inch by one inch. This construction allows the carbons to receive the spark at breaking the circuit, but as the resistance of the carbons is too great to give sufficient current to the solenoid by carbon only, the metal contacts are made in addition. (In adjusting these contacts, allow very little lead of the carbons, otherwise the period of contact of the metal contacts is made too short to allow the reciprocation of the core of the solenoid.)

The signal is shown in Fig. 267.

A composition case forms the chamber for the wire terminals, the space for conduit terminals, the lugs furnished with rubber cushions which receive the impact of the core-case when the circuit is closed, and the lugs for securing the whole to the bulkhead. The composition case has two lugs cast on its upper part to which are secured one end of each of the two steel guide rods on which the core-case travels; the other end of each rod is passed through a brass washer and spiral spring and is connected to a composition cross-piece which has a rubber cushion on its center; the rubber cushion together with the spiral springs on the rods serve as buffers to receive the weight of the core-case when the circuit is opened. A water-tight cover of composition is fitted on the top

of the case, which, when removed, exposes the wire terminals. Each wire terminal has a 3-ampere link fuse mounted on a porcelain block; the fuses are more often omitted.

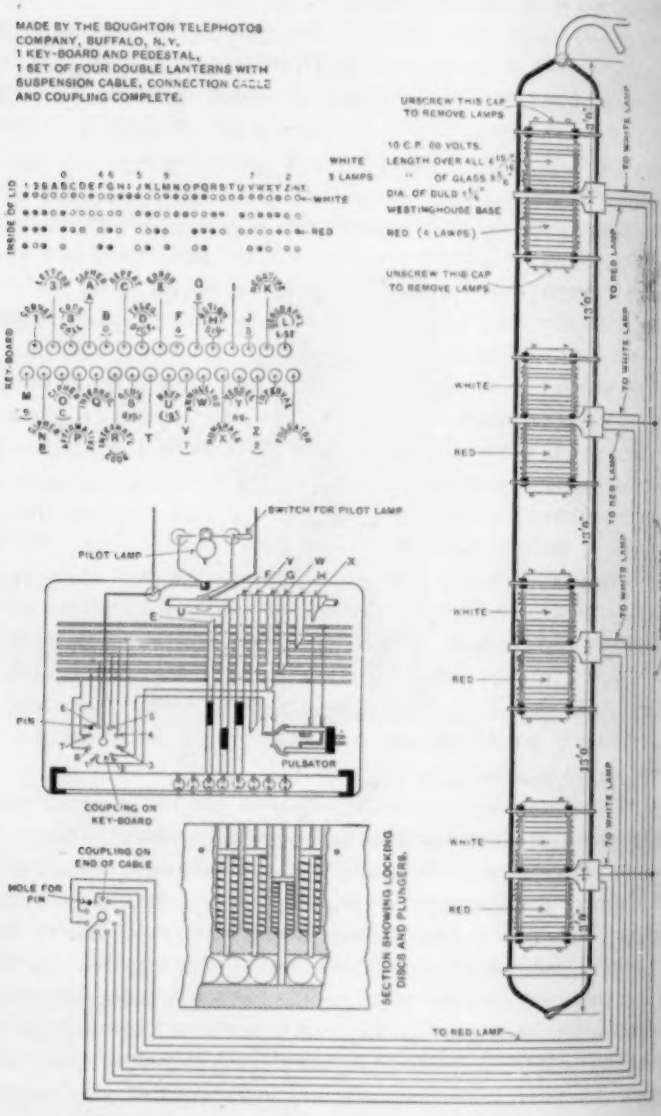


FIG. 268.—Connections and arrangement for the telephotos.

The solenoid coil is secured to composition case and is encased in a brass cylinder; it has a hollow center about one inch in diameter.

The iron core-case, forming an air chamber below the solenoid, is a hollow cylinder fitting closely over the outside of the coil and inside the composition case. It is closed at the bottom and carries the core of soft steel which projects into the solenoid coil. The whistle is attached to the bottom of the case. Four lugs are cast on the core-case, two of which fetch up against the cushioned lugs on the composition case when the core is drawn up into the solenoid coil. The other two lugs serve as guides for the guide rods.

When the circuit is closed by the circuit closer, the current flows through the solenoid coil, exerting a strong pull on the core and its case; there being no escape for the air in the air chamber of the cylinder, except through the whistle, it gives a shrill sound. When the circuit is broken by the circuit closer, the coil releases its pull and the core and case drop upon the two spiral springs and rubber cushion. At this time the circuit closer again closes the circuit and the whistle is made to sound as before, this reciprocating action, lasting for about 35 seconds, gives a succession of short, sharp whistles.

Adjusting screws are placed on the rocker arm of the escapement which control the speed of unwinding of the main spring; increasing the distance between screws, makes the apparatus work more slowly, and vice versa.

To give an alarm, depress the lever (on the outside of the circuit closer) as far as it will go and then release it. This winds up the main spring (requiring a period of about 35 seconds in unwinding) making and breaking the circuit repeatedly.

Keep the contacts of the circuit closer properly adjusted.

Inspect fuses in the solenoid to see that none have burned out.

Keep the core-case clean; if it becomes oxidized it will not work freely in the outer cylinder.

If a ground occurs it will likely be caused by the breaking down of the insulation of the solenoid coils. To locate this, disconnect the terminals of each solenoid in succession and test out until the ground is found.

See that the switch handle always returns to its initial position, otherwise the circuit may be left closed and burn out the solenoid coils; such a case has occurred.

The signals are installed in parallel.

Owing to the liability of burning out the coils in the signals when the contact remains closed, after the clock-work has run down, a deck fixture is installed in the dynamo-room in which is a 16-candle-power lamp coated with a red lacquer. This gives a visual indicaton of the fact that the circuit is still closed.

Night Signal Set.

The object of the night signal set is to provide a device which will rapidly and accurately transmit, from one station on shipboard to another distant station, by means of lights, a prearranged code of signals, when darkness prevents other means of visual signalling. The classes of service on which the method is employed is in signalling from one vessel to another, for squadron or fleet maneuvers and for communication between vessels and cooperating military commands on shore.

Three types are in use: Two types of the General Electric Company, and the "Telephotos," the design of the Boughton Company; the present difference is mainly in the keyboard.

Either type of set consists of four essential parts: *A keyboard*, by which the connections for the individual signals are made; *a cable*, connecting the keyboard contacts to the separate lamps of the lanterns; *four double lanterns*, the upper half of which is red and the lower half white; and *a lamp ladder*, on which the lanterns are suspended and which suspends the principal weight of the lanterns and cables to an outrigger on the mast. The cables and lamp ladders for both types of night signal sets are now the same and the cables are of the type described under standard wire.

The lamp ladders are of the construction shown in Fig. 268 for the original telephotos type. At the top and bottom are two composition spreaders into whose ends are spliced two wire ropes, of seven No. 12 B. & S. G. galvanized iron wire, ¼-inch diameter. The center of the upper of these spreaders is to be attached to the outrigger by a shackle; to the lower is shackled a jumper, of the same wire rope as is used for the sides of the ladder, if the ladder can be seized to a backstay, or up to ¾ inch if all is set flying; the jumper is set up by a turnbuckle to the channels, to the ship's side, or to a deck plate, to steady the ladder assembly from swinging about in the wind, or from motion of the ship.

The spreaders for suspending the lanterns are of composition

with a score in their T-shaped ends into which the side rope is seized with copper seizings and soldered. These spreaders go in pairs and are spaced a sufficient distance to secure the lanterns by chains to their middle eye, a small amount of slack being allowed in the bottom chain that the lantern may assume a normally perpendicular position. The distances between centers of lanterns is standardized at 12 feet, but 8-foot and 10-foot distances are common; the governing rule is that the upper lantern should show below the signal yard and the lower above the top of the

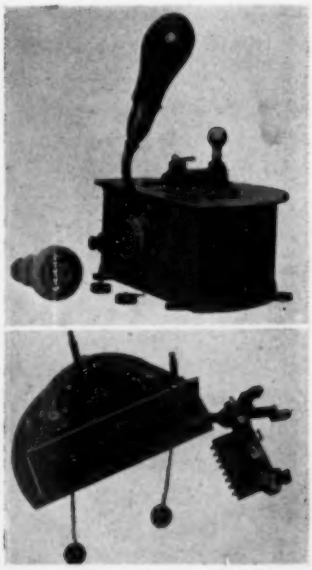


FIG. 269.—Keyboard, semi-circular type, General Electric Company.

smoke pipe; when the height of the mast permits, the upper lantern may show above the signal yard and the second below it. The spacing between the lamps should be as near the standard 12 feet as the particular ship's design will admit in order to distinctly separate the lights when viewed from a distance.

The outrigger is of wrought iron and is clamped to the mast to set at an angle of 45 degrees abaft the athwartship plane, to starboard, whether installed on the fore, or on the main (or mizzen) when two night signal sets are furnished flagships. For the method of securing the cable wires to the coupling: Eight wires

are soldered together and connected with the inside (common return) socket pin of the coupling, the remaining eight being connected to the remaining eight pins; a slot on the coupling engages a lug on the socket of the keyboard to ensure proper assemblage.

Keyboard, General Electric Company, Semi-circular Type.—The keyboard (Fig. 269) consists of a water-tight box, of semi-circular cross-section, containing the contact-making mechanism. The edge of the top plate is marked for 30 lamp indications and 56 interpretations, the indications being shown as red and white countersunk and filled dots in consonance with the lights to be shown in the lanterns, below are marked the interpretations as a convenient guide. On the back are two receptacles for 25-ampere attachment plugs, and a female coupling which connects by spring contacts with the eight peripheral contact plates of the coupling (shown) and a central pin which enters the socket connections for the common return of the coupling.

The keyboard is illuminated by a 16-candle-power lamp supported on a goose-neck.

The interior mechanism, Fig. 269, consists of eight ⅛-inch cast composition contact plates, secured to the top plate by three stud bolts, the contact plates being insulated from each other by pieces of 1⅛-inch O. S. D. rubber tubing to space the plates three-eighths of an inch; the plates are assembled on the assembling bolts by nuts which are insulated by hard rubber washers. The inner edges of the plates are so fitted with hard rubber sections as to break and make contact for the lantern lamps desired.

The necessary contacts are made by a rotating stud (Fig. 269) containing eight plungers working against internal springs which keep the plungers in continual contact with the inner periphery of the plates, making electrical contact or not accordingly as the plunger is opposite a metal or insulated section. The shaft of the rotating stud is secured by an insulated guide bracket secured to each of the assembling bolts, and extends water-tight and insulated up through the top plate where the operating handle is secured by clamps.

The revolving stud is supplied with a single-pole, horizontal knife switch which is insulated from the stud, and by means of the small handle on the keyboard (shown on top of the revolving stud shaft) pulsates the indication of the upper lantern which may be in circuit at the time.

The operating arm consists of a casting with a removable cover on the under side. A single-pole, vertical knife switch secured to the opposite side of the revolving stud, but insulated from it, operates all the lamps, and is operated by a lever within the arm which is raised, and connection made by spring action, when the knob of the operating handle is down, and is depressed by a lug on the operating handle when the knob is up. A cam lug on the operating handle engages a slot on the top plate, so that the arm cannot move, and locks the handle at the desired signal; bevelling

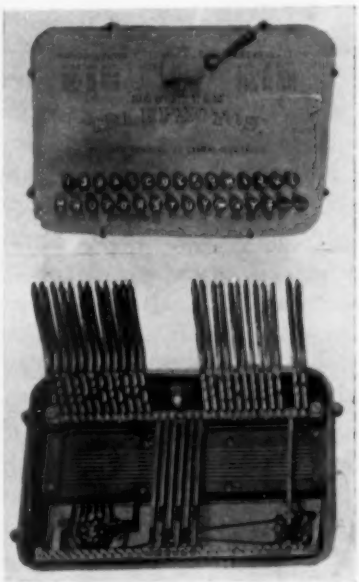


FIG. 270.—Telephotos keyboard and inner cover.

the edge of the cam and slots will increase the speed of signalling. When the operating handle is in a vertical position the cam lock is disengaged, and the arm can be moved to any other indication, the pointer at the end registering with the center of the signal to be made.

Current is supplied from the signal circuit to a 25-ampere switch and receptacle, and from thence to the keyboard by two conductors, fitted at each end with a 25-ampere, water-tight attachment plug.

With current switched on the circuit, as shown by the illuminating lamp, the various combinations represented by the dial are made to appear by moving the operating handle to the indication, depressing the handle and making connection through to the proper lamps in the four lanterns; by then operating the pulsating lever the lights in the upper lantern are pulsated. For instance: With the operating handle vertical, move the arm until the pointer is at the center of the desired signal; depress the handle, thereby closing the circuit through the knife switch on the back of the revolving stud; the current flows from the switchboard feeder, by way of the transfer switch to the signal circuit and by the switch and receptacle to one of the line receptacles on the key board; thence to the contact rings; to the vertical knife switch; to plungers (as affected by insulating plates); to the contact plates; to the cable by outer coupling contacts; to lamps in lanterns; back to the cable; to central contact in coupling and then through the line connection to the signal circuit, etc.

Gaskets should be inspected and renewed when the rubber hardens from long compression or partially vulcanizes from the heat of the metal, especially in tropical climates. The cable should be occasionally painted with a waterproof preservative compound.

The keyboard is usually supplied with a sheet-brass cover with conical top in which is a door for access.

When not in use this door should be kept closed, and the cover be protected against weather by a canvas hood.

The Telephotos Keyboard.— The device (Figs. 268 and 270) consists of a cast composition box, with an inclined cover so designed as to exclude water when not in use; the upper plate on the inside is packed water-tight in case of exposure. The interior is illuminated by a 5-candle-power lamp mounted on a goose-neck, the connections being paralleled across the entering leads. The standard coupling and line receptacles are the same as for the General Electric Company keyboard (although earlier forms are still in service) and are mounted on the back of the case. The cable connections as far as the coupling, coupling receptacle and lanterns are concerned are shown in Fig. 269.

The cover plate within the box is a composition casting pierced for the fitting of 31 hard rubber bushings which form the guides for the shanks of the stops. There are 31 stops, each consisting of a copper rod to which is fitted a hard rubber cap; the stops

give 30 lamp connections for a total of the standard 56 interpretations, one stop being the pulsator connection. The shank of the stop is fitted with a shoulder which takes against and depresses one of the 30 contact levers.

The levers are hinged at the back of the box, the hinges having a spring which keeps the lever out of contact with the eight wires shown, and which are strung across the box and secured over insulation at either side; each wire is connected to one of the spring contacts in the coupling receptacle. Beyond the shoulder the shank of the stop is extended to operate the locking device; this device consists of a V-shaped trough of metal extending across the box under the centers of the stops, the curve being at one side. In the trough are placed a number of nickel-plated, composition balls, only sufficient play being given to admit of the passage of one stop shank between two contiguous balls; hence when a stop is pushed the balls are moved under the shanks of all other stops and effectually prevents two displays at the same time; the interval and pulsating stops are independent of the locking device.

The levers (Fig. 270) are designed with lugs to connect only to those wires (strung across the box) as will bring into circuit the necessary lantern lamps, and the wires and lugs are tipped with platinum against arcing.

Pulsating is accomplished by leading the two connections for the upper lamp of the upper lantern through a make and break switch (shown) contact being broken on depressing the stop. Current is supplied from the signal circuit to a 25-ampere switch-and-receptable from which double conductors connect to the keyboard box and to the rod on which the levers hinge, through the levers to the box wires, to the lamp connections at the coupling, to the lamps, back by the common return to the center connection of the coupling and its receptacle and thence to the other 25-ampere line receptacle, the 25-ampere switch and receptacle, submain, transfer switch and feeder line to the switchboard.

This type of keyboard is ordinarily mounted on a pedestal, in that case the line wires come up through the pedestal.

The availability of keyboards in general depends mainly on their adaptability for signal speed; the speed is limited to the condition that the glow of one signal shall cease before the next signal is made.

General Electric Company's Keyboard, Latest Type.—This keyboard, whose mechanism as removed from the enclosing case is shown in Fig. 271, very much resembles the telephotos type. The plunger system and balls to prevent coincident signals is the same, but each plunger is made to connect to the eight busbars by wire connections to a system of spring contacts, current being afforded to the eight circuits through the springs by dynamo potential by the contacts of the plungers.

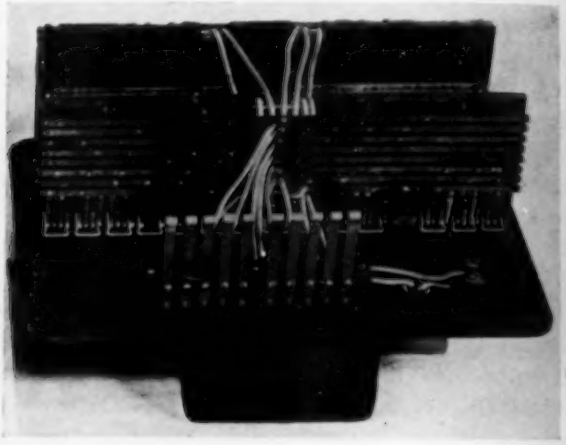


FIG. 271.—Interior of General Electric Company's keyboard, latest type.

In a modification of this device the Mustin warming-up principle is incorporated. By this principle a flow of current is continually kept up in the busbar circuits, a resistance being inserted and of sufficient amount to keep the potential below that which would cause the lamps to glow; as a result of the arrangement the time necessary to warm up the lamps—and an appreciable time—is saved, and when the lamps are switched off they cease to glow in a much shorter time; hence, the glow being cut off and caused quicker, the speed of signalling can be materially increased; and this proves successful in practice.

General Alarms.

The type most installed is that shown in Fig. 272.

The gong is 12-inch, and is struck by a clapper, operated by a clock-work mechanism, which is released by an electromagnet, and

controlled by a push button. The gong is of the single-stroke type.

The clock-work is of a heavy design, and all practicable parts are nickle-plated, to prevent corrosion. The specified operation is to strike once every half second for not less than 30 seconds, with capacity for one repetition. The release of the mechanism is to be complete on one pressure of the push button.

The push button for closing the circuit is of the usual W. T. and N. W. T. type, according to location, but is protected by a cover requiring removal before operating in order that no false alarms may be sent.

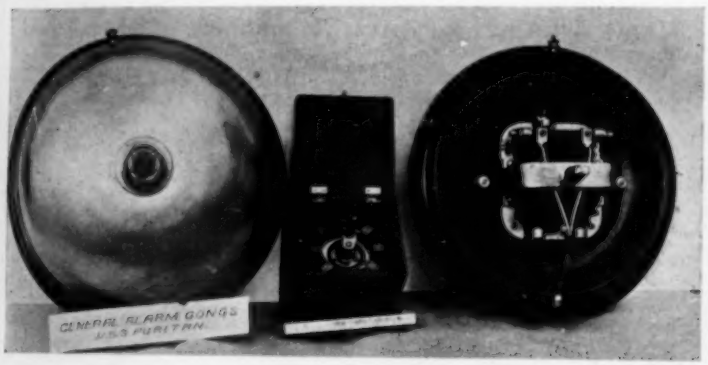


FIG. 272.—General alarm gong.

The results of tests as to the volts and amperes to operate a single gong on various lengths of circuit are as follows:

LINE IN CIRCUIT. Feet.		Ohms. Res. Total.	MIN. GOOD OPERATING. Volts.			Amps.
Length.	Run.		Gong.	Line.	Total.	
0	0	0	1.290	0	1.29	.216
100	50	.463	1.371	.109	1.48	.235
200	100	.868	1.383	.207	1.59	.238
300	150	1.275	1.403	.307	1.71	.241
400	200	1.689	1.413	.407	1.82	.241
600	300	2.523	1.361	.581	1.95	.230
800	400	3.338	1.405	.785	2.19	.235
1000	500	4.179	1.382	.978	2.36	.234
Average						.234
Strokes for each winding						175

The resistance of the coils is 5.64 ohms.

The line consists of 50 feet of 20 conductor interior communication cable connected non-inductively to represent 1000 feet of line resistance.

In the test each release was made when the gong was fully wound and three releases gave sixty strokes each to full winding.

The contact maker consists of a contact lever, normally held off from the contact ring by a spring, so that in operation the contact is made by the natural pressure of the hand.

By rotating at a natural rate the contact with the ring is closed and the current is applied to the gongs.

The gongs when installed are divided into two sections.

Turret Hoist-and-Ready and Ammunition-Car-Position Indicator.

This device is described on page 1245.

Whistle Operator.

The principle of operation of this apparatus is to afford an automatic or at will method of electrically operating a specially constructed valve controlling the admission of steam to the steam whistle.

The valve and operating case is installed in the steam-pipe connection to the whistle and the electric operation is independent of the hand pull which is connected to a lever usually marked "Emergency Hand Pull." The main valve is of a special globe type and arranged to be kept normally shut by the pressure of steam or to be reclosed by such pressure when forced open; it is independent of the auxiliary valve for hand control. The stem of the valve extends up and out through the casing. The magnet case contains two multiple-wound electromagnets, over which is a heavy armature operating against a spring, and carrying a hollow sleeve on a guide post. The sleeve ends in the solid rod working through a stuffing box in the bottom of the operating case.

When the magnets are energized the armature is attracted and, pushing down the sleeve and consequently the rod, comes in contact with the valve stem of the auxiliary valve admitting steam to the whistle. When the current is cut off, the valve closes automatically under the unbalanced pressure of steam.

The connections are shown in Fig. 273. There are two places of control; an automatic and at will control in a brass, locked

operating case, usually located in the chart house; and a three-way automatic and at-will switch, with lever, usually located conveniently on the bridge.

The Mechanism of the Operating Case.—The case contains (Fig. 273):

First, a clock (indicated by the arrows) with a rotary make-and-break circuit switch; making the circuit at intervals of 54 seconds and continuing the contact for six seconds, thus giving a continuous blast of the whistle for that interval. This automatic

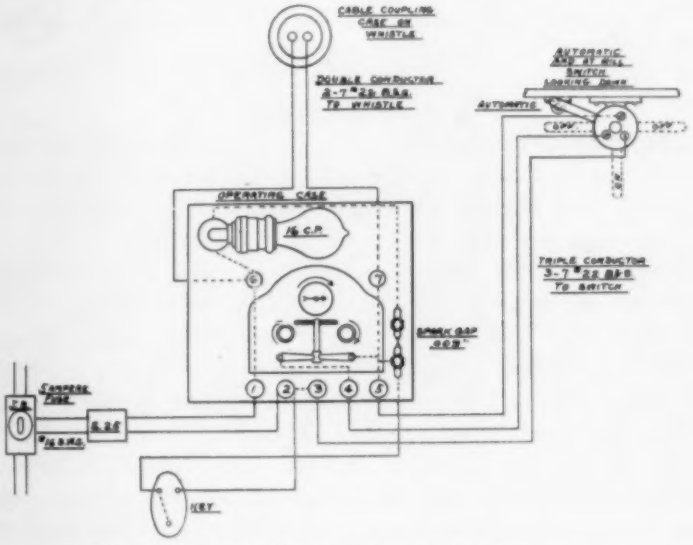


FIG. 273.—Connections of the whistle operator.

arrangement is wound up to be set in motion during fog. *Second,* a key of simple make-and-break circuit type located on the door. This at will arrangement admits of using the whistle for signalling purposes. *Third,* a lamp resistance in the spark gap circuit. *Fourth,* a spark gap for discharging the high voltage of self induction due to the magnet.

The Automatic and At-Will Switch.—This lever switch of special construction is so designed that it can be used to start the clock mechanism and thus engage the automatic, or take the place of the key in the operating case for signal use.

Tracing the connections of Fig. 273 from the junction box

and switch: First, the positive (lower) leg leads to binding post then to the key, to one contact of the spark gap, to (to the left) the connection through to the cable coupling case and back to the line; or second, from the bridge switch by the bridge switch to the operating case and through to the cable coupling and back to line; or third, from the operating case to the bridge switch through the bridge switch back to the operating case to a special contact which is connected to the rotary switch of the clock mechanism and out to the cable coupling and back to line.

There are, therefore, three individual operating circuits in parallel of which two are at-will and one is automatic.

The bridge switch shows by its name plate which way the lever is to be moved to ensure proper operation.

Telephones.

The most successful types that have been installed are those of the American Bell Telephone Company and mainly for the reason that the "solid-back" button style of microphone does not harden so readily and thereby influence the action.

For various uses five forms have been designed and of which three are still in use: Number 1, having a large wooden case enclosing the bell and similar to the type usual in commercial use; Number 4, having a small wooden case; Number 5, similar in external appearance to Number 4, and shown in Fig. 274; the last has been installed in the greatest number.

The transmitter of the Bell telephone, common in its speaking details in all forms, is shown in Fig. 275, the separate parts being shown at the side. This instrument is capable of standing a very heavy current without heating and the tendency of the granules of carbon in the button to settle down into a compact mass, commonly called "packing," is greatly diminished. *Even with so efficient a microphone as this button used with the Bell designs, packing is very likely to occur as a result of gun-shock and the telephone become unreliable;* less efficient designs can therefore be expected to fare worse.

Referring to Fig. 275, *F* is the front piece of the transmitter case and is held in the hollow case *C*, the two pieces forming a complete metallic casing for the working parts of the instrument. The sound-receiving diaphragm *D* is encased in a soft rubber ring *e* and is held in place by two damping springs *ff*. *W* is a heavy

metallic block hollowed out to form a casing for the electrodes; the inner circumferential walls of this block are lined with a strip of paper *i*. This block is mounted on a supporting rod *P* secured at its end to the outer casing of the transmitter. The back electrode *B*, of carbon, is secured to the face of the metallic piece *A* which is screw-threaded into the block *W*. *E* is the front electrode, also of carbon, carried on the face of the metallic piece *b*. On the enlarged screw-threaded portion *p* of the piece *b* is slipped a mica washer *m* held in place by a nut *u*. This washer is of sufficient diameter to completely cover the cavity in the block *W*, when the electrode is in place. After the required amount of

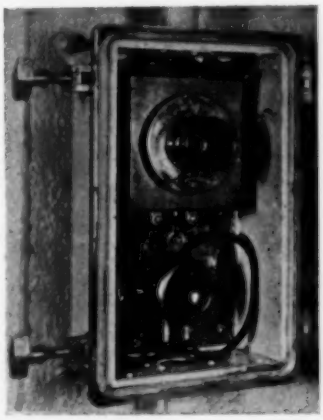


FIG. 274.—Bell telephone, No. 5.

granular carbon has been put into the cavity and the front electrode put in carbon the cap *c* is screwed in its place on the block *W* and binds the mica washer *m* firmly against the face of the block *B*, thus confining the granules in their place. The electrodes are of somewhat less diameter than the paper-lined interior of the block *W*, so that there is a considerable space around the periphery of the former, which is filled with carbon granules; this prevents the binding of the free electrode against the edge of its containing chamber, and also allows room for the granules which are directly between the electrodes to expand when heated by the passage of current. The screw-threaded portion *p* of the piece *b* passes through a hole in the center of the diaphragm, and is clamped

firmly in place by the two nuts *tt*. *M* is the mouth-piece of hard rubber, screw-threaded in an opening in the front block *F*. Any vibration of the diaphragm is transmitted directly to the front electrode *E* which is allowed to vibrate by the elasticity of the

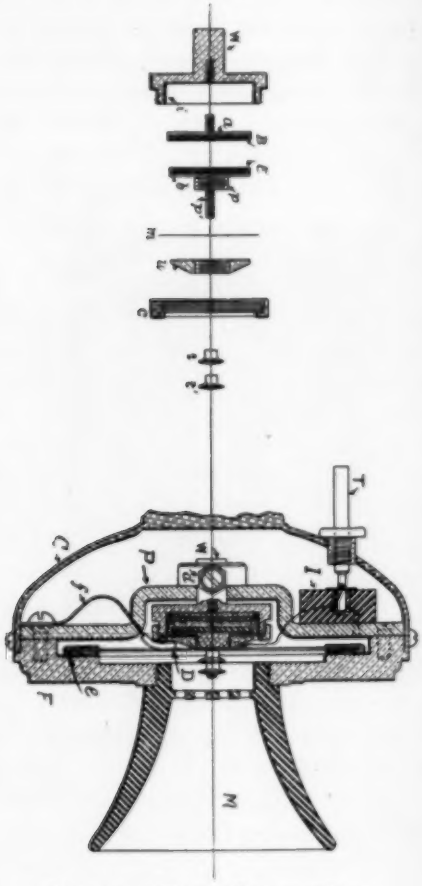


FIG. 275.—The Bell transmitter.

mica washer *m*. The back electrode is stationary, being firmly held by the bridge rod *P*.

For large installations the practice on many ships has been to connect the telephones up on a common talking circuit, with a separate ringing circuit. The limitations of the number of simultaneous conversations in the form of connection, are now over-

come on the large vessels by a switchboard, with an operator constantly in attendance who can move the connections for a number of separate and simultaneous conversations up to seven or nine. The extra cost and weight of the ringing circuits are eliminated by utilizing a plan of corrections similar to that in large city exchanges where it is only necessary to lift the receiver from the hooks to call up central. The same lines of commercial practice are followed in the use of lamp indicators at the central station

FIG. 276.—Cory type of telephone.

with a talking and ringing current from specially constructed motor generators.

The Cory Type of Telephone.—A device commonly installed of late is the Cory telephone shown in Fig. 276. Its main features are the double-ear tubes with rubber pads, the idea being to protect the ears from extraneous noises.

In a later device an arrangement is added by which the diaphragm can be tapped to counteract packing of the button.

The receivers used are not essentially different from those or-

dinarily used with commercial telephones, whether of the long or watch-case variety; or when self-contained.

The Time-Firing Device or Stoking Indicator.

There are three varieties of this type of apparatus which differ in so many important details that only one will be described as giving a general idea of the intent of all.

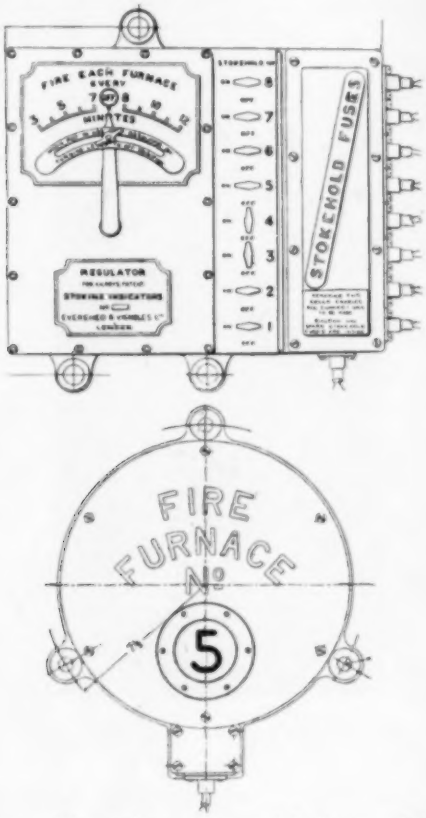


FIG. 277.—Diagram of face of regulator and indicator of Kilroy time firing device.

The Kilroy Device.—The apparatus has been devised for the purpose of facilitating uniform firing of boilers and thus to secure a maximum coal efficiency and a minimum of smoke production. To carry out the intention of the device it is necessary to mark each furnace door with a brass number as painted or chalk figures

are too easily obliterated. An indicator is placed in each fire-room and is constructed to show the number of the furnace which is to be fired next in definite rotation and at the same time ring a loud gong to attract attention; all indicators are actuated electrically by one regulator or transmitter placed in one of the engine rooms.

The regulator, transmitter, or timing apparatus consists of a

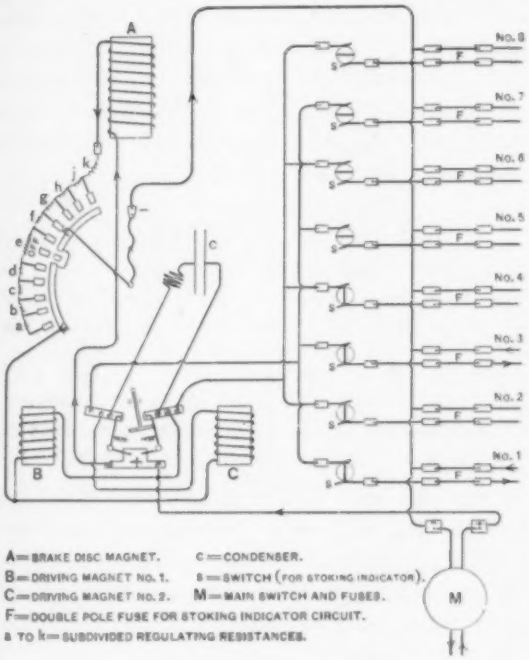


FIG. 278.—Connection of time-firing device.

special switch mechanism which closes electrical circuits at uniformly recurring intervals of time and these recurring closures actuate the indicators, the switch mechanism being so designed that the fire-room indicators do not all ring simultaneously, the arrangement being that the minimum number of furnace doors shall be open at one time. A regulating lever is provided to enable the engineer in charge to vary the rate of firing at will; the lever over the scale marked " firing interval in minutes " being movable, and the designed firing interval being the time in minutes between two successive appearances of the same number on the indicator

and hence the interval between two successive firings of the same furnace; for example, let the regulator be set for eight minutes' interval, then the time between two successive appearances of the same number on the indicator will be eight minutes and in this period a complete rotation of numbers will have occurred; if the fire-room indicators show numbers from 1 to 8 (corresponding to a similar number of furnace doors) each fire-room will show a new number and ring a bell once a minute, and so on. A set of switches is provided, one for each indicator, so that only those indicators which are necessary need be switched into circuit. When once switched into circuit the apparatus works automatically and requires no attention. A diagram of the faces of the regulator and of the indicator are shown in Fig. 277, and the general electrical connections in Fig. 278.

[NOTE 31.—As a rough rule for determining the quantity of coal required at each firing, the following may be taken as a typical case: Assuming that each boiler is to be worked at an output of 450 h. p. and that the coal consumption is 2 lbs. per i. h. p. hour, then the coal burnt per boiler will be 900 lbs. per hour; and (taking the weight of a shovelful of coal as 10 lbs.) this will be 90 shovelfuls in 60 minutes for each boiler. If eight minutes has been decided upon as the firing interval, the number of shovelfuls required for firing each boiler during that interval will be 12. If each boiler has four furnaces this will mean three shovelfuls in each furnace door every time its corresponding number appears on the indicator.]

Circuits are led off from a lighting circuit to the combined main switch and fuses *M* (Fig. 278), the path of the current being from the positive terminal of the regulator, through the automatic switch, to either one of the driving magnets *B* or *C*, and so to the negative terminal. The electromagnets act alternately upon a pivoted soft iron armature which communicates its motion through gear wheels to a plain copper disc, and this disc, rotating in the field of another electric magnet, acts as a Foucault or eddy current brake. The winding of the brake magnet and its variable resistance form with the winding of the driving magnet two parallel circuits across the total potential in order that the relation between the pull on the soft iron armature by the driving magnet and the retarding force on the copper disc any action of the brake magnet field may remain practically independent of changes of voltage.

The two driving magnets are arranged symmetrically about the axis of the soft iron armature, and but one is energized at the

same time. The automatic switch, depending for its action on the motion of the soft iron armature, serves to break the circuit of one magnet and make that of the other when the armature has moved in one direction or the other to the end of its swing; this motion of the armature—first one way and then the other—and the consequent similar rotations of the brake disc are continuous and automatic as long as the apparatus is switched on.

The automatic switch, besides directing the current to the driving magnets switches off and on at the same time the circuits to the fire-room, and the indicators are actuated at each reversal of the regulating armature. The time between successive reversals is determined by the position of the lever on the face of the regulator which is mechanically coupled to an inner contact arm which in turn varies the resistances shown and which are in series with the brake magnet. The resistances are wound with wire of constant temperature coefficient.

Upon the armature spindle of the automatic switch is mounted a small disc, having at its periphery a discontinuous guard flange in two parts and also an arm-piece, all of which oscillate with the soft iron armature. To the ends of the arm-piece are fixed two spiral springs connected at their other ends to two points one on each side of the axis of the switch. The upper end of the switch terminates in a fork which is itself clear of the disc, but each end of the fork has a projecting pin which engages against the outside of one of the flange guards. When the armature has completed part of its oscillatory travel, the springs tend to make the automatic switch pass over to its other oblique position, but a pin prevents its movement until the armature has completed its stroke; the tension of one of the springs then sharply brings over the automatic switch to its alternative position, when the contacts on one side are let down and the contacts on the other side are broken, and thus the motion is reversed.

A condenser (Fig. 278) with a resistance in series, is connected across the brake to overcome the spark which can be considerable on account of the induction in the broken circuits.

Each indicator consists of an outer case protecting the bell; this is mounted in an inner water-tight case which also contains the mechanism for moving the dial marked for the numbers of the furnace doors. When the current is on and the soft iron magnet is magnetized, an armature is attracted and a single stroke

rung on the bell. An inner armature then acts on a cup wheel and drives the wheel one step to the next indication of the dial, and both armatures return by the action of their springs without changing the number shown and are set ready for the next operative stroke.

Referring to the connection diagram it will be noted that when a fire-room switch is on at the regulator the corresponding indicator has current half the time only.

Notes on the Use of the Device.

To obtain accuracy when setting the "timing interval" place the regulator lever on the "off" position in the middle of the scale and then move it slowly to the desired mark.

On a 125-volt circuit the regulator takes about 0.2 ampere and each indicator about 0.1 ampere. Since the main fuses blow at about 5 amperes, larger fuse wire than that provided must not be used.

When the apparatus is not in use turn off the main switch.

Place the regulator in such a position that both covers and glands will be readily accessible, and that the regulator may not be subjected either to excessive heat or vibration. Do not remove the cover of the regulator.

The center of the indicator should not be less than 6½ feet nor more than 8½ feet above the floor plates.

The Blinker Light.

This device is used as an auxiliary means of signalling by wigwag code employing a flashing light for the purpose.

The device is shown in Fig. 279 and consists of a cylinder whose upper part is cut away to give an all-around view; for mechanical construction the three ports are separated by strips of the side of the cylinder ¾ inch in width and located on the 120-degree arcs. Covering the ports inside is a hollow cylinder whose lower end is closed and to this end is screwed a rod which extends down and out through the bottom of the outer cylinder where it is finished with an eyebolt to which attaches a line and toggle. Pulling on the toggle opens the outer ports and causes a flash, the inner cylinder being returned to cover the ports by the action of a spring under its base.

A bail with an eye permits hanging the device where convenient. A length of double conductor, plain, with water-tight attachment plug is fitted through a stuffing tube in the top, in order that convenient receptacles may be utilized. The lamp is of 32-candle-power and is set in a type-A socket.

Bridge Semaphore, 2-Arm.—The device as made thus far has been constructed in the general form of Fig. 280. The two upper

FIG. 279.—The blinker light.

FIG. 280.—Bridge semaphore, 2-arm.

arms are used as shape signals in the day time; they are also fitted with three lamps each for night use. The lower arm is a day indication for the vessel to which the signal is making, the operator having it on his right hand when facing that vessel.

At the top is a fixed red light which serves as a mark point for fixing the attention of observers when awaiting signals; this light is screened for all directions excepting that in which the signal is to be sent.

When installing on vessels in which the bridge is exposed to the blast of the 8-inch guns, the opening of the standard should be inboard to facilitate unshipping when clearing ship for action.

On some vessels it has been found advisable to install on the boat cranes.

The arms are operated independently by the cranks and sprockets shown.

The Fiske 4-Arm or Masthead Semaphore, or Day-Signalling Device.—This apparatus is a shape-signalling device supplementing the night-signalling set for day use.

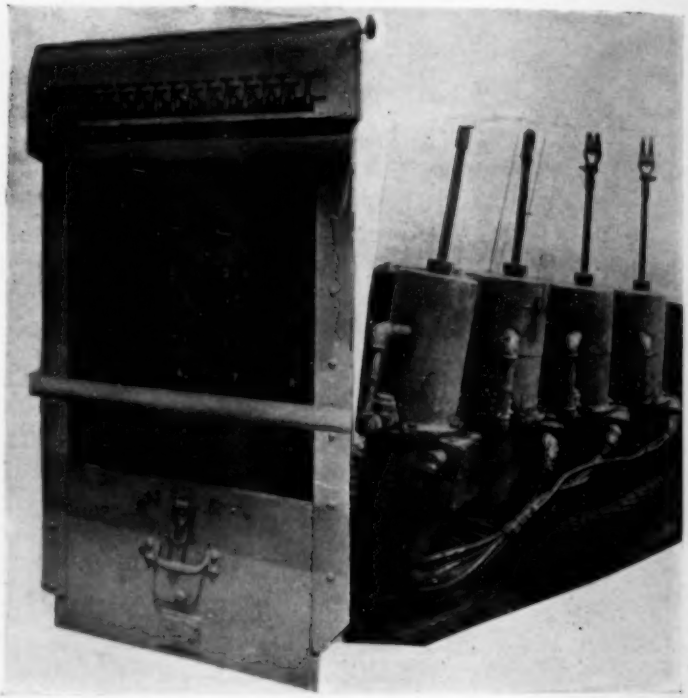


FIG. 281.—Keyboard (left) and double solenoids of Fiske day-signalling device.

The shapes are four light vanes set on shafts from band clamps on the masts and which can be moved to an angle of 45 degrees, to the horizontal or back to a normal vertical position, corresponding to the red, white and out indications of the night-signalling set, or to the 1, 2 and 3 positions of the wigwag code. The vanes are center pivoted (a feature which gives best working conditions under wind pressure) and are moved by a simple lever at-

tachment on their rear side with a stop to prevent motion beyond the horizontal position; the vertical, or off position is regained under the action of springs. The actuating force of the vanes is a set of four double solenoids located in the fore or upper top, to the spindle of whose plungers is attached a wire rope which leads to the lever on the vane and which has two legs at the solenoid end (Fig. 281); any slack of the rope is taken up by turnbuckles. The double solenoid is necessary for the two positions which each vane is to assume, one actuating to the 45-degree position and the other drawing the plunger still farther until the vane is in the horizontal position and brings up against the stop.

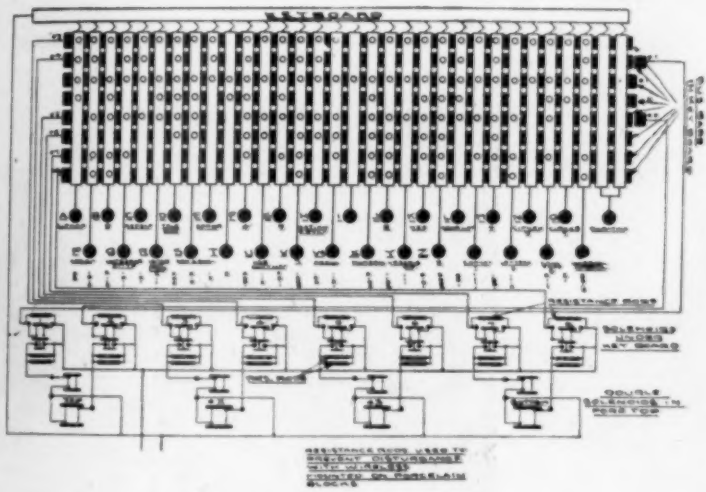


FIG. 282.—Connections Fiske day-signalling device.

The keyboard is shown in Fig. 281, left. It has the same number of keys (31) as that for the telephotos (Fig. 270) and these make connection to the eight solenoids shown in the base by a lever system whose principle is in general similar. The rods of the plungers of these eight solenoids close the contacts of the eight circuits to the four actuating solenoids in the foretop, the contacts being of carbon on account of the heavy sparking from induction; four of the keyboard solenoids connect with the upper of the double solenoids, while the other four make connection with both the upper and lower of each double solenoid and in series as shown in the connection diagram (Fig. 282); hence one

set of four solenoids serves to turn the vanes to the 45-degree position while the other four accomplish the horizontal and therefore any combination of the three positions for separate vanes is possible by a suitable arrangement of the key contacts.

A more convenient method for signalling is to install two sets of vanes, one set looking fore and aft and the other athwartships; with this arrangement both sets work simultaneously, one set is operated by the double solenoids and the other through gears from the first.

The heavy sparking of the keyboard solenoid contacts together with their location on the after bridge is found to interfere with the reception of wireless messages; this can be remedied by shunting each contact with a high carbon resistance and reducing

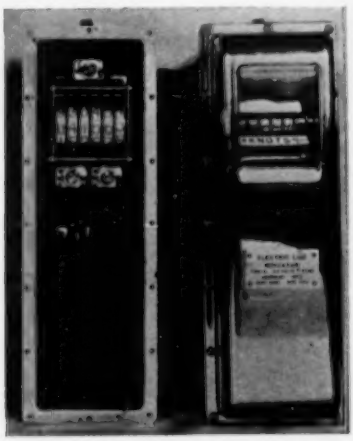


FIG. 283.—Indicator for electric log.

the effects of induction by installing part of the cable leading to the double solenoids in conduit; the conduit must of course be grounded, but this will usually be the case when attached to bare metal.

Electric Log Indicator.

The object of this device is to give in the Chart House, without resource to passing the word along the deck, the readings of the log and also to show a totalled record.

The Transmitter.—This consists of the usual log indicator modified to make and break an electric circuit. It is mounted on

a bracket which clamps to an awning stanchion and extends outboard horizontally. At the outer end of the bracket a hole is drilled vertically for the pivot of the trunnion yoke and a screw at right angles engages in the groove of the yoke to prevent running out. On the second gear is mounted a Tobin bronze cam insulated from the spindle by a hard rubber bushing, but turning with the spindle to which it is firmly secured by means of a hard rubber key. The cam makes one turn for every 88.2 turns of the rotator, or at the speed of one knot per hour it makes one-sixth of a turn per minute. The contact device consists of a rigid contact and a spring contact mounted on a hard rubber block which is secured to the case of transmitter. On top of spring is fixed a boss

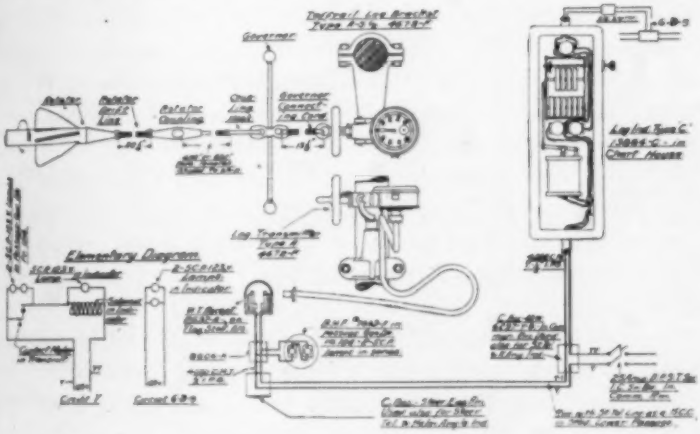


FIG. 284.—Connections of electric log (*Connecticut*).

adapted to be engaged by the cam on the spindle. The boss is so shaped that when the cam releases, the contact arm can snap up and make a quick break in the circuit.

To prevent the damage that might ensue if the log were from any reason turned in the wrong direction the worm wheel is mounted loosely upon its spindle and is driven by a pawl which will release when the direction of rotation is reversed. The contacts are made by two circular brass discs, each having an annular groove in which a platinum wire is set. These discs can be loosened up if sparking has made it desirable and a new portion of the platinum put in position to supply the contact surfaces. The amounts of surface furnished at the discs will admit of a long

period of service with shifting, as found necessary. Two 5-candle-power lamps connected in series are shunted across the contact maker to reduce sparking to a minimum. If the transmitter from any cause becomes inoperative the lamp in the indicator will either remain permanently lit or cease to glow at regular intervals. In either case the stopping of the instrument would soon become noticeable.

The Log Indicator (Fig. 283).—The log indicator is located in the chart house and is a counter which is actuated by a plunger in a solenoid. The readings on counter indicate tenth of knots on the right-hand figure and knots on left-hand figures. The readings on the dials of the transmitter are unchanged and readings can be taken there independently whether the electric counter is working or not. The solenoid is inclosed in an ironclad frame with a hollow core. The ironclad construction is adopted to prevent the leakage of magnetic lines which would affect the compass in the vicinity.

The upper end of the plunger rod is attached to the center of a lever; one end of the lever being pivoted to a lug on the frame of the solenoid while the free end is attached to a rod carrying an escapement operating a star-pointed wheel fastened to the counter mechanism.

The bore of the solenoid is lined with a brass tube in which a plunger is lifted by the action of the magnetic field; lifting the escapement moves the star-pointed wheel and the counters are revolved.

There are three 5-candle-power 123 volt lamps installed inside the case. Two of these are connected directly to the lighting mains and are used to illuminate the dials. The other lamp shunts the solenoid and is used as an indicator and glows when current passes through the solenoid.

All contacts must be kept clean. The ball bearings, gear train bearings, cam surfaces, and pawl driven worm wheel should be oiled. The escapement in the indicator should be oiled before using. The circuit is on the dynamo potential taken from the interior communication panel in the central station.

A diagram of the connections is shown in Fig. 284.

CHAPTER XV.

NOTES ON INSTALLATION.

Preliminary Considerations.

The initial factor in determining a scheme of installation is *the voltage,* for upon this depends the construction of many devices, especially the power apparatus. The present standard is 125 volts; many ships have 80 volts, and auxiliaries have commonly 110 volts.

The second consideration is what may be termed the *method of installing;* that is, whether the method shall be for molding, conduit or insulator, or a combination of two or all.

[Note 32.—As to a system, the two-wire has been the invariable practice; three-wire work is installed in the *Kearsarge* and *Kentucky* but only in connection with the speed of certain motors whose supply lines, being also fed two-wire for the lower voltage, constitutes rather a five-wire supply for the multivoltage (80 and 160 volts) plan than a three-wire system as commonly accepted.

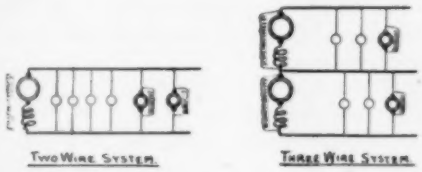


Fig. 285.—Illustrating two-wire and three-wire systems.

The commercial advantages of the three-wire system are two—an important saving of copper in the leads, and the availability of two voltages for motor speed. These can be explained in the following example:

Referring to Fig. 285, left, the dynamo is supplying (omitting the motor) four lamps on the two-wire system and taking ½ ampere each at an average distance L and maintaining a potential of 100 volts at the lamps; hence each lamp takes 50 watts, and the four lamps, 200 watts. The circuit must evidently carry two amperes. From the formula for wire size (page 1226), and allowing three per cent drop, the circular mills

$$= \frac{2 \times L \times 2 \times 10.87}{3} \qquad (1)$$

The two dynamos of Fig. 285 right, are connected in series on their inside poles and from this connection the middle wire (or "neutral") is

run. They are feeding their outside wires from the positive pole of one dynamo and the negative of the other. The four lamps are shown connected from the outside wires to the neutral, the neutral acting as positive to the two lower lamps and as negative to the two upper. The arrangement may be regarded as two sets of two lamps in parallel, the two lamps of each set being in series. Since the potential of the two outside wires is double that of either dynamo taken singly, the potential at the lamp terminals of each series is 200 volts; and, as each series requires but ½ ampere the expended energy for the system (omitting the motor) is 200 watts; the current, however, will be but *one ampere*. From this it is evident that the current required for the three-wire system is but half that required for the two-wire. Again the drop for the double potential can be twice that for the single and the circular mills

$$\frac{2 \times 2L \times 10.83}{2 \times 3} \qquad (2)$$

Comparing (1) and (2) it is seen that the wire size in circular mils necessary for the three-wire system is but *one-fourth of that for the two wire*. Calculating this for saving in copper for the three-wire, as compared with the two-wire for the lower voltage, the saving will be in the ratio of 1½ : 2, a saving of copper of 62½ per cent; or, following the common custom of making the neutral wire one-half the size of the outside wires, the saving will be in the ratio of 1⅜ : 2, a saving of 68¾ per cent. This saving, though in somewhat lower percentages in practice, is an important economical consideration in commercial line constructions where the distances of transmission are great.

The motor in the two-wire diagram evidently receives one-half the terminal potential of that in the three-wire, hence its speed is approximately halved without rheostatic loss.

The copper saving and speed considerations are outweighed in man-of-war installations, because *first*, the life of the wire is somewhat reduced; *second*, the lines of wiring are materially short in comparison; *third*, it is found that it is not necessary to resort to multivoltage control of speed, that is, great ranges are not required; *fourth*, the system necessitates the use of two dynamos at the same time; *fifth*, the multivoltage plan requires five wires instead of three and there is really increased cost instead of saving.]

The method of installing is dependent upon the nature of the duct to be employed; the line of appliances, etc., being different for molding, insulators and conduit. Experience lays down the following rules as to a selection.

I. The best method is a complete conduit installation throughout the ship.

II. As a consideration of the saving of weight in the ship's construction insulators may be used in certain locations where water-tightness is not necessary, or mechanical injury to the wiring is not likely.

APPLIANCES.										KILOW	
Division.	Number of Each.	Per Cent. Full Load Required.							Each.	Total.	Action—Quarters.	
		Action.		Cruising.		Anchor.						
		Day.	Night.	Day.	Night.	Day.	Night.	Display.			Day.	Night.
Equipment Lighting.												
Lighting Fixed	393 16-C.P.	0	0	75	100	75	100	100	.....	22.35	.....	.....
" Portable	109 16-C.P. 6 1-C.P.	0	0	50	50	25	50	50	.....	6.24	.....	.....
Battle Fixed	403 16-C.P. 124 5-C.P.	100	100	100	100	75	75	75	.....	25.39	25.39	25.39
" Portable	2 150-C.P. 413 16-C.P. 18 5-C.P.	100	100	75	75	25	25	25	.....	25.08	25.08	25.08
" Arc Lights	10	100	100	100	100	0	0	0	.375	3.75	3.75	3.75
Search Lights—60 in.	2	0	50	0	50	0	0	100	25.00	50.00	.....	25.00
" " 30 in.	4	0	75	0	50	0	25	100	10.00	40.00	.....	30.00
Motors:												
1/4 H.P. Portable Vent. Sets	8	100	100	50	0	50	0	0	.375	3.00	3.00	3.00
1/6 H.P. Fans	8	20	20	75	75	75	75	75	.133	1.06	.21	.21
1/12 H.P. Fans	58	10	10	75	75	75	75	75	.006	3.83	.38	.38
Dough Mixer	1	0	0	100	0	100	0	0	2.50	2.50	.....	.....
Dish Washer	1	0	0	100	0	100	0	0	.84	.84	.....	.....
Meat Chopper	1	0	0	100	0	100	0	0	.81	.81	.....	.....
Potato Peeler	1	0	0	100	0	100	0	0	.98	.98	.....	.....
Motor Generators:												
Turret Turning—12 in.	2	67	67	0	0	0	0	0	30.88	61.76	41.17	41.17
" " 8 in.	4	67	67	0	0	0	0	0	19.24	76.96	51.10	51.10
Gun Elevating—12 in.	4	75	75	0	0	0	0	0	7.29	29.16	21.87	21.87
" " 8 in.	8	50	50	0	0	0	0	0	4.08	32.64	16.32	16.32
Wireless Telegraph	1	100	100	100	100	100	100	100	5.00	5.00	5.00	5.00
Telephone System—J	1	100	100	100	100	100	100	100	.39	.39	.39	.39
Dynamotor for Int. Comm. System	1	100	100	100	100	100	100	100	.22	.22	.22	.22
Admiral's Circuit—A. Ward Room Officers' Circuit—B. Junior Officers' Circuit—C. Warrant Officers' Circuit—D. Voice Tube Calls Circuit—E. Fire Alarm Circuit—F. General Alarm Gong Circuit—G. Engine Rev. Ind. Circuit—K.												
Running Lights and Signals	18	0	50	0	72	0	44	44	.....	2.10	.....	1.05
Night Signals	3	0	33	0	33	0	33	33	.52	1.56	.....	.52
Truck Lights	2	0	50	0	50	0	50	0	.12	.24	.....	.12
Somaphores—4-arm	1	100	0	100	0	100	0	0	.....	3.50	3.50	.....
" 2-arm	2	0	50	0	50	0	50	50	.49	.98	.....	.49
Whistle Operator	2	50	50	50	50	0	0	0	.012	.024	.01	.01
Watertight Door Indicator	47	100	100	100	100	100	100	100	.02	.94	.94	.94
Warning Signals	1 16-C.P. 17 Signals.	100	100	100	100	0	0	0	.....	2.27	2.27	2.27
Fire Control:												
Hoist and Ready Signals and Ammunition Car Position Indicator	12 Fixtures.	100	100	0	0	0	0	0	.056	.67	.67	.67
Torpedo Firing	4	50	50	0	0	0	0	0	.66	2.64	1.32	1.32
Electric Log Indicator	1	0	0	100	100	0	0	0	.21	.21	.....	.....
Helm Angle Indicator	4	100	100	100	100	0	0	0	.02	.08	.08	.08
Steering Telegraph	2 Trans. 2 Indicators.	100	100	100	100	0	0	0	.02	.06	.06	.06
Engine Telegraph	4 Trans. 2 Indicators.	100	100	100	100	0	0	0	.02	.08	.08	.08
Fire Room Timing Device and Indicator	1 Regulator. 6 Indicators.	100	100	100	100	0	0	0	.....	.25	.25	.25
Illuminating Outfit	1	0	0	0	0	0	0	100	.....	34.50	.....	.....
Navigation Instruments	.....	0	26	0	26	0	0	0	.....	.51	.....	.13
Heaters:												
Smoothing Irons—8 lbs.	1	0	0	100	0	100	0	0	.62	.62	.....	.....
" " 7 lbs.	1	0	0	100	0	100	0	0	.60	.60	.....	.....
Soldering Pot	1	100	0	100	0	100	0	0	.46	.46	.46	.....
Soldering Iron—1½ in.	1	100	0	100	0	100	0	0	.28	.28	.28	.....
" " 1 in.	2	50	0	50	0	50	0	0	.10	.20	.10	.....
Ordnance Motors.												
Gun Elevating and Depressing—12 in.	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
" " " " 8 in.	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Gun Rammers—12 in.	4	75	75	0	0	0	0	0	9.25	37.00	27.75	27.75
" " 8 in.	8	50	50	0	0	0	0	0	2.63	21.04	10.52	10.52
Ammunition Hoists—12 in.	4	75	75	0	0	0	0	0	48.75	195.00	146.25	146.25
" " 8 in.	8	50	50	0	0	0	0	0	12.63	101.04	50.52	50.52
Torpedo Air Compressor	2	100	100	0	0	0	0	0	65.63	131.26	131.26	131.26
C. & R. Motors.												
Ventilation (outside armor):												
45-in. Steel Plate Fan	1	0	0	67	67	67	67	67	2.83	2.83	.....	.....
Ventilation (inside armor):												
80-in. Steel Plate Fan	2	100	100	67	67	67	67	67	9.44	18.88	18.88	18.88
60-in. " " "	5	100	100	67	67	67	67	67	5.01	25.05	25.05	25.05
55-in. " " "	2	100	100	67	67	67	67	67	4.06	8.12	8.12	8.12
50-in. " " "	2	100	100	67	67	67	67	67	4.16	8.32	8.32	8.32
45-in. " " "	5	100	100	67	67	67	67	67	2.83	14.15	14.15	14.15
40-in. " " "	2	100	100	67	67	67	67	67	2.00	4.00	4.00	4.00
35-in. " " "	1	100	100	67	67	67	67	67	1.50	1.50	1.50	1.50
30-in. " " "	2	100	100	67	67	67	67	67	1.78	3.56	3.56	3.56
No. 6 Monogram Exhaust Fan	1	100	100	67	67	67	67	67	2.31	2.31	2.31	2.31
No. 4 " " "	8	100	100	67	67	67	67	67	.96	7.68	7.68	7.68
No. 2 " " "	2	100	100	67	67	67	67	67	.69	1.38	1.38	1.38
Turret Turning—12 in.	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
" " 8 in.	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ammunition Hoists, Chain—7 in.	12	50	50	0	0	0	0	0	1.73	20.76	10.38	10.38
" " 3 in.	14	50	50	0	0	0	0	0	1.73	24.22	12.11	12.11
" " Whip	6	50	50	0	0	0	0	0	2.50	15.00	7.50	7.50
" Conveyor	4	100	100	0	0	0	0	0	3.75	15.00	15.00	15.00
Boat Crane, Hoisting	2	0	0	100	100	100	100	100	29.38	58.76	.....	.....
" " Rotating	2	0	0	101	100	100	100	100	16.25	32.50	.....	.....
Deck Winch	6	0	0	10	0	50	50	0	18.44	110.64	.....	.....
Pumps, Fresh Water	2	100	100	100	100	50	50	50	1.85	3.70	3.70	3.70
" Sanitary	2	100	100	100	100	100	100	100	3.12	6.24	6.24	6.24
Power Doors and Hatches	47	31	31	31	31	0	0	0	1.03	48.29	15.00	15.00
Laundry	1	0	0	100	0	100	0	0	7.31	7.31	.....	.....
Steam Engineering Motors.												
Universal Milling Machine	1	100	100	50	0	50	0	0	2.25	2.25	2.25	2.25
Lathe—38 in.	1	100	100	50	0	50	0	0	8.38	8.38	8.38	8.38
Small Drill Press	1	100	100	50	0	50	0	0	.25	.25	.25	.25
Large Drill Press	1	100	100	50	0	50	0	0	1.50	1.50	1.50	1.50
Lathe—14 in.	1	100	100	50	0	50	0	0	1.25	1.25	1.25	1.25
Grinder	1	100	100	50	0	50	0	0	2.25	2.25	2.25	2.25
Shaper	1	100	100	50	0	50	0	0	4.38	4.38	4.38	4.38
Medicine and Surgery.												
TOTALS, K.W.											717.07	770.04

Generating Sets—Either Dynamo Room (Normal Rating) 100 K.W. Each—400 K.W. Total.	Sets and K.W. in Operation	4—400	4—400
	Connected K.W. in Excess of Requirements	—317.07	—370.04
	Sets and K.W. in Reserve (Normal)	.....	.....
Overload Capacity—Either Dynamo Room (1⅓ Rating) 133 K.W. Each—533 K.W. Total.	Sets and K.W. in Operation	4—533	4—533
	Connected K.W. in Excess of Requirements	—184.07	—237.04
	Sets and K.W. in Reserve (1⅓ Rating)	.....	.....
Generating Sets—Two Dynamo Rooms (Normal Rating) 100 K.W. Each—800 K.W. Total.	Sets and K.W. in Operation	8—800	8—800
	Connected K.W. in Excess of Requirements	82.93	29.96
	Sets and K.W. in Reserve (Normal	.....	.....

al.	KILOWATTS REQUIRED.							REMARKS.
	Action—Quarters.		Cruising.		Anchor.			
	Day.	Night.	Day.	Night.	Day.	Night.	Display.	
35	.....	.....	16.76	22.35	16.76	22.35	22.35	
24	.....	.....	3.12	3.12	1.56	3.12	3.12	
79	25.39	25.39	25.39	25.39	19.04	19.04	19.04	List 16223-A.
08	25.08	25.08	18.81	18.81	6.27	6.27	6.27	
75	3.75	3.75	3.75	3.75	.....	.....	.....	
00	.....	25.00	.....	25.00	.....	.....	50.00	
00	.....	30.00	.....	20.00	.....	10.00	40.00	
60	3.00	3.00	1.50	.....	1.50	.....	.....	
06	.21	.21	.80	.80	.80	.80	.80	
83	.38	.38	2.87	2.87	2.87	2.87	2.87	
50	.....	.....	2.50	.....	2.50	.....	.....	2½ H.P. 1340 R.P.M. Eff. —%.
84	.....	.....	.84	.....	.84	.....	.....	¾ H.P. 900 R.P.M. Eff. 75%.
81	.....	.....	.81	.....	.81	.....	.....	¾ H.P. 1800 R.P.M. Eff. 71%.
98	.....	.....	.98	.....	.98	.....	.....	1 H.P. 1500 R.P.M. Eff. 71%.
78	41.17	41.17	.....	.....	.....	.....	.....	2 25-K.W. Motor Generators. 1500 R.P.M. Eff. 78.5%.
06	51.10	51.10	.....	.....	.....	.....	.....	4 15-K.W. Motor Generators. 1500 R.P.M. Eff. 76%.
16	21.87	21.87	.....	.....	.....	.....	.....	4 5½-K.W. Motor Generators. 1850 R.P.M. Eff. 71.3%.
64	16.32	16.32	.....	.....	.....	.....	.....	8 3-K.W. Motor Generators. 1800 R.P.M. Eff. 70.1%.
00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	1 3-K.W. Motor Generator. 1800 R.P.M. Eff. 58%.
39	.39	.39	.39	.39	.39	.39	.39	¼ H.P. 1500 R.P.M. Eff. 40%.
22	.22	.22	.22	.22	.22	.22	.22	¼ H.P. 1800 R.P.M. Eff. 40.9%.
10	.....	1.05	.....	1.51	.....	.93	.93	
56	.....	.52	.....	.52	.....	.52	.62	
24	.....	.12	.....	.12	.....	.12	.....	1 Double Controller, 2 Lights.
50	3.50	.....	3.50	.....	3.50	.....	.....	List 16927-A.
98	.....	.49	.....	.49	.....	.49	.49	
024	.01	.01	.01	.01	.....	.....	.....	
94	.94	.94	.94	.94	.94	.94	.94	
27	2.27	2.27	2.27	2.27	.....	.....	.....	
67	.67	.67	.....	.....	.....	.....	.....	
64	1.32	1.32	.....	.....	.....	.....	.....	2 Directing Stations; 4 Torpedo Tubes.
21	.....	.....	.21	.21	.....	.....	.....	
08	.08	.08	.08	.08	.....	.....	.....	4 Indicators; 1 Arc.
06	.06	.06	.06	.06	.....	.....	.....	1 Transmitter and 2 Indicators used at one time.
08	.08	.08	.08	.08	.....	.....	.....	2 Transmitters and 2 Indicators used at one time.
25	.25	.25	.25	.25	.....	.....	.....	
50	.....	.....	.....	.....	.....	.....	34.50	12220-C. Lighting for 4 Pelorus, 16-C.P. Lamps, one used at a time.
51	.....	.13	.....	.13	.....	.....	.....	Navigation Inst. " " 3 Binnacles, 5-C.P. Lamps, one used at a time.
								" " 4 Mech. Eng. Tel., 5-C.P. Lamps, two used at a time.
32	.....	.....	.62	.....	.62	.....	.....	" " 6 Eng. Rev. Ind., 5-C.P. Lamps, two used at a time.
60	.....	.....	.60	.....	.60	.....	.....	" " 1 Log Ind., 2 5-C-P. Lamps, two used at a time.
46	.46	.....	.46	.....	.46	.....	.....	
28	.28	.....	.28	.....	.28	.....	.....	
20	.10	.....	.10	.....	.10	.....	.....	
...	.....	.....	.....	.....	.....	.....	.....	8 H.P. 420 R.P.M. Eff. %. Load shown in Motor Generator.
...	.....	.....	.....	.....	.....	.....	.....	5 H.P. 540 R.P.M. Eff. %. Load shown in Motor Generator.
00	27.75	27.75	.....	.....	.....	.....	.....	10 H.P. 1000 R.P.M. Eff. %. Not used while hoisting.
04	10.52	10.52	.....	.....	.....	.....	.....	3½ H.P. 750 R.P.M. Eff. %. Not used while hoisting.
00	146.25	146.25	.....	.....	.....	.....	.....	55 H.P. 400 R.P.M. Eff. %.
04	50.52	50.52	.....	.....	.....	.....	.....	17 H.P. 600 R.P.M. Eff. %.
26	131.26	131.26	.....	.....	.....	.....	.....	80 H.P. R.P.M. Eff. %.
								[NOTE.—As no tests were made on Ordnance Motors, name-plate data were used.]
89	.....	.....	1.89	1.89	1.89	1.89	1.89	3.75 H.P. 730-980 R.P.M. Eff. %.
88	18.88	18.88	12.59	12.59	12.59	12.59	12.59	12 H.P. 490-525 R.P.M. Eff. %.
05	25.05	25.05	16.70	16.70	16.70	16.70	16.70	6.3 H.P. 605-730 R.P.M. Eff. %.
12	8.12	8.12	5.43	5.43	5.43	5.43	5.43	5.8 H.P. 615-820 R.P.M. Eff. %.
32	8.32	8.32	5.55	5.55	5.55	5.55	5.55	4.6 H.P. 670-930 R.P.M. Eff. %.
15	14.15	14.15	9.43	9.43	9.43	9.43	9.43	3.75 H.P. 730-980 R.P.M. Eff. %.
00	4.00	4.00	2.67	2.67	2.67	2.67	2.67	2.6 H.P. 800-1080 R.P.M. Eff. %.
50	1.50	1.50	1.00	1.00	1.00	1.00	1.00	2.2 H.P. 9-0-1225 R.P.M. Eff. %.
56	3.56	3.56	2.37	2.37	2.37	2.37	2.37	1.65 H.P. 1115-1485 R.P.M. Eff. %.
31	2.31	2.31	1.54	1.54	1.54	1.54	1.54	2.7 H.P. 830-1190 R.P.M. Eff. %.
68	7.68	7.68	5.12	5.12	5.12	5.12	5.12	1.1 H.P. 1080-1450 R.P.M. Eff. %.
38	1.38	1.38	.92	.92	.92	.92	.92	.75 H.P. 1750-2125 R.P.M. Eff. %.
...	.....	.....	.....	.....	.....	.....	.....	35 H.P. 400 R.P.M. Eff. 90.3%. Load shown in Motor Generator.
...	.....	.....	.....	.....	.....	.....	.....	15 H.P. 400 R.P.M. Eff. 88.2%. Load shown in Motor Generator.
76	10.38	10.38	.....	.....	.....	.....	.....	3 H.P. 400 R.P.M. Eff. 81%.
22	12.11	12.11	.....	.....	.....	.....	.....	3 H.P. 400 R P.M. Eff. 81%.
00	7.50	7.50	.....	.....	.....	.....	.....	3 H.P. 1150 R.P.M. Eff. 78%.
00	15.00	15.00	.....	.....	.....	.....	.....	4 H.P. 500 R.P.M. Eff. 84%.
76	.....	.....	58.76	58.76	58.76	58.76	58.76	53 H.P. 400 R.P.M. Eff. 90.35%. Not used while rotating.
50	.....	.....	32.50	32.50	32.50	32.50	32.50	90 H.P. 365 R.P.M. Eff. 88.4%. Not used while hoisting.
34	.....	.....	11.06	.....	55.32	55.32	.....	25 H.P. 350 R.P.M. Eff. %.
70	3.70	3.70	3.70	3.70	1.85	1.85	1.85	2 H.P. 1000 R.P.M. Eff. 80%.
24	6.24	6.24	6.24	6.24	6.24	6.24	6.24	3 H.P. 1050 R.P.M. Eff. 79%.
29	15.00	15.00	15.00	15.00	.....	.....	.....	1 H.P. 1200 R.P.M. Eff. 67%.
31	.....	.....	7.31	.....	7.31	.....	.....	8 H.P. 900 R.P.M. Eff. 81%.
25	2.25	2.25	1.13	.....	1.13	.....	.....	2 H.P. 800-1600 R.P.M. Eff. 69%.
38	8.38	8.38	4.19	.....	4.19	.....	.....	7½ H.P. 740-1675 R.P.M. Eff. 80%.
25	.25	.25	.13	.....	.13	.....	.....	¾ H.P. 1400 R.P.M. Eff. %.
50	1.50	1.50	.75	.....	.75	.....	.....	1 H.P. 1200 R.P.M. Eff. %.
25	1.25	1.25	.63	.....	.63	.....	.....	1 H.P. 600-1500 R.P.M. Eff. 70%.
25	2.25	2.25	1.13	.....	1.13	.....	.....	2 H.P. 910-1825 R.P.M. Eff. %.
38	4.38	4.38	2.19	.....	2.19	.....	.....	5 H.P. 400-1200 R.P.M. Eff. 80%.
								[NOTE.—When omissions occur data are not obtainable at this time.]
	717.07	770.04	270.63	283.28	270.88	260.44	319.50	
..	4—400	4—400	3—300	3—300	3—300	3—300	4—400	
..	—317.07	—370.04	29.37	16.72	29.12	39.56	80.50	
.	.....	.....	1—100	1—100	1—100	1—100	.....	
..	4—533	4—533	3—400	3—400	3—400	2—267	3—400	
..	—184.07	—237.04	129.37	116.72	129.12	6.56	80.50	
..	.....	.....	1—133	1—133	1—133	2—267	1—133	
..	8—800	8—800	3—300	3—300	3—300	3—300	4—400	
..	82.93	29.96	29.37	16.72	29.12	39.56	80.50	
..	.....	.....	5—500	5—500	5—500	5—500	4—400	

III. Any combination of conduit and molding or insulators for economical reasons is usually restricted to the plan of using conduit exclusively in the following locations (molding or insulators may be used in other locations):

1. All locations below the protective deck.
2. All exposed leads on decks open to the weather.
3. Galleys, bakeries, machine shops, and evaporator rooms.
4. Drum rooms and spaces connecting with the fire- and engine-rooms.
5. Ice-machine and cold-storage rooms.
6. Wash rooms and heads.
7. All vertical runs requiring overhauling or renewal.

Determination of Generator Units and Supply.

The total supply of electrical energy, and the selection of the number and size of units, is based upon three main considerations: *First,* that the units shall be of the same size, in order that all parts may be interchangeable; *second,* that the units shall be of the largest sizes of generator which a convenient division of the output will admit; *third,* that at least one unit shall be in reserve, in excess over the total output demanded (33 per cent overload considered), that it may be kept turning over slowly and sufficiently to avoid water hammer, and be in readiness to parallel in on the load in case of accident to or failure of any other unit.

A tabulation of the various divisions of the energy, in convenient form, is first made as in the preceding table for the *Connecticut.*

In the first column is shown the various divisions of duty to which the total output is distributed. Column 2 shows the number of each type of the various divisions which are installed, those opposite the divisions for lighting being the number of lamps or outlets to be supplied. Columns 3 to 9 show the estimated ratios of the numbers in column 2 which will probably be in use when in action, or at sea or in port for day and night. Column 10 contains the kilowatts necessary for each of the numbers in column 2 which is based on kilowatt consumption. By multiplying the numbers in column 2 by the quantities of column 10, column 11 is derived, and shows the total kilowattage demanded of the source of supply were every division of supply furnished with full-rated energy; its total and details are mainly for reference.

The remaining columns are the actual demands of service use for their particular occasion, estimated on the actual requirements and probabilities of use as derived by multiplying the ratios in columns 3 to 9 by the quantities of column 11.

Columns 12 and 13 show the requirements for action in battle, or general quarters, for day and night service. Columns 14 and 15 show the ordinary demands on the plant, by day and by night, when the ship is underway. Columns 16 and 17 show the ordinary demands of the plant when the ship is at anchor, or moored to dock, and the main engines are not in use. Column 18 shows the probable demands on the plant when the ship is illuminated *en fête*. The totals of these columns (12 to 18) evidently afford a good guide as to the load to be anticipated on the several occasions, and form the basis for the determination of the number of units that will be required to be operated at the particular time.

Inspection of the totals of columns 12 to 18 develops that the greatest demand on the output for the *Connecticut* will be in night action, and that the fair probability is that 770 k. w. must be supplied at some given time; it may be that all turrets, etc., may not be in operation at the same instant, but it is wiser to provide for such a contingency, especially for time of action, however remote.

On the basis of the 770 k. w. demanded, selecting the smallest number of standard units of the same size, and assessing the operating units at 33 per cent overload (a requirement for two hours operation on acceptance and intended for more protracted operation in emergency) the *Connecticut* requires six generating sets of 100 k. w. size. As a matter of fact the ship has eight 100-k. w. size units, four in each of two dynamo-rooms widely separated in the ship. Four 200-units would be up-to-date.

Analysis of the Divisions of Load.

Lighting Locations and Installation.—The location of the individual outlets, whether for fixed or portable lights, is a matter which is quite independent of their feeders and mains, and can well be taken up first, for the reason that outlets are primarily independent in the requirements of location, and can later be assembled into submains, according to the control required for their service locations, and for keeping their energy within the limits which may be prescribed by the specifications for the mains and feeders.

Elevations Above the Deck.—To afford proper accessibility in installation, operation, repair, and distribution of light for the service required, the following distances above the deck should be used whenever practicable in installing on bulkheads, stanchions, etc.:

Switches, junction boxes, distribution boxes, switch-and-receptacles, receptacles, battle lantern brackets, portable hooks, double receptacles, desk light hooks, 5 feet; fans and fan brackets, 5½ feet; bulkhead lights (standing) to bottom of globe, 2½ feet.

Light Distribution.—The nature of the outlets on the lighting circuits (including lighting and battle circuits) and their disposition in the different locations on board ship, are usually assigned as in the following scheme for a battleship. The general requirements for any shipboard installation are practically the same, though differing in number of outlets for ships of smaller size and different type. The actual number of each type of outlet is not given, except as restricted; as the number will depend upon the class and size of ship.

Standard of Illumination.—The rule for *overhead lighting* is that at least one 16-candle-power lamp shall be installed for every 500 cubic feet of space in the following locations:

Berthing spaces.	Blacksmith shop.
Cabin, admiral's.	Cabin, captain's.
Reception room, admiral's.	Reception room, captain's.
Chart house.	Contagious ward.
Galleys.	Offices.
Dynamo-rooms.	Engine rooms.
Fire-rooms.	Turret-handling rooms.
Ice-machine rooms.	Operating rooms.
Sick bay.	Evaporator rooms.
Emergency cabins.	Cabin, chief of staff.

Uses of Fixtures and Receptacles.—The general uses of the fixed outlets for lighting purposes are:

Ceiling Fixture No. 1.—This fixture is for overhead lighting only, and its use should be restricted to the overhead lighting of the cabins for the admiral, captain and chief of staff, and any passages connected therewith; reception rooms, admiral's and captain's; the wardroom countries and passages in front of staterooms; cabin staterooms; messrooms aft.

Ceiling Fixture No. 3 is used for overhead lighting only and replaces ceiling fixture No. 1 for the following locations:

Staterooms for the admiral, captain and chief of staff; staterooms of other officers when the installation of an overhead fixture is assigned; chart houses; emergency cabins; contagious ward; offices; countries and mess rooms of junior officers and warrant officers; passages in quarters not lighted by a ceiling fixture No. 1; operating room and sick bay.

The fixture gives a larger area of reflection of light than the ceiling fixture No. 1 and greater illuminating power, especially if fitted with a clear glass globe.

Commercial Ceiling Fixture.—This type is installed in lieu of ceiling fixture No. 3 in staterooms, offices and the like when a smaller type of fixture will answer and when some overhead lighting seems advisable.

Bracket fixtures are installed for the side lighting of cabin and wardroom countries and reception rooms. They are intended also as a reading light, and the double or single type is installed as best suits the location. A single bracket is installed on each side of all sideboards.

Binnacle Light Fixture.—The two types are a part of the binnacle construction.

Turret-Hood Fixture.—This fixture is installed in the position most convenient for its use as explained in its description.

Telegraph fixture is an attachment for electric lighting of mechanical telegraphs only and is really a part of the device.

Double Receptacle.—This type of wiring appliance outlet is intended principally as a terminal for locations when a desk light and a fan are to be plugged in, as in staterooms and offices. The rule is that when a desk light and a fan are to be allowed for the location, this type of outlet is to be used. It is to replace the non-water-tight receptacles.

Deck, Bulkhead and Drop Fixture.—All overhead lighting other than that prescribed for ceiling fixtures No. 1 and No. 3 is accomplished by the deck, the bulkhead or the drop fixture.

The deck fixture is generally to be preferred, if the head room admits, as it gives a large area of illumination. It is sometimes an advantage, when the head room is great, to attach a bulkhead fixture to hang below the beam and bring the lamp lower than would be practicable with the deck fixture.

The bulkhead fixture should never be installed for overhead lighting when it will be exposed to leakage and drip of water, or when the compartment is to be subject to the access of steam; the globe will not be water-tight in such locations due to its horizontal position. If lighting is desirable on both sides of a bulkhead it should be provided by separate lights.

The drop fixture is used for overhead lighting when the available securing position of a deck fixture would be too high up for good distribution of light, and mainly in engine-rooms, fire-rooms and their connections. When the conduit connection to the drop fixture is over four feet long the fixture should be steadied by at least three stay chains or wires, four are preferable.

The bulkhead fixture is used for all side lighting (except when bracket fixtures are installed) in living or berthing spaces; and is so installed that the bottom of the globe shall be 30 inches above the level of the deck. On decks usually inhabited by the ship's crew, one bulkhead (side) light should be installed about every third frame apart to afford convenient light for reading and sewing.

Neither of the three types should ever be installed in storerooms unless the storeroom is one which is not to be locked and is to be usually occupied by a storekeeper or other person.

Switches-and-receptacles and Receptacles (5-ampere) are for attaching portables or may be used as the single outlet for a desk light or a fan.

Specific Lighting of Compartments and Locations.

The following distribution, derived from the installation of the *Connecticut* indicates the method of lighting the various compartments and locations *not already referred to,* and for the manner of lighting described.

Air Locks.—Deck fixtures if the head room admits, otherwise a bulkhead fixture overhead.

Ammunition Conveyers.—Deck or bulkhead fixtures, according to the locations available, at side or overhead. Also a switch-and-receptacle for a portable which is to be used in examination or repair of the motor and running gear; to be specially installed if one is not already located within convenient distance for some other intermittent use.

Ammunition-Hoist Motors and Hand-Operating Gear Panels.—The same as for Ammunition Conveyers.

Ammunition Passages.—Deck lights in preference to side bulkhead lights, to give a better general distribution of the light and keep the glare of the lights above the eye line.

Armory.—The same as for ammunition passages and for the same reasons.

Ash Chutes.—A deck fixture, if not already sufficiently lighted by adjacent fixtures installed for other purposes.

Ash Hoists (Upper End).—A deck fixture, if not already sufficiently lighted by adjacent fixtures installed for other purposes. Also a switch-and-receptacle for a portable, for examination of the engine at the lower end.

Bakery.—Bulkhead fixtures so located as to show inside the ovens when the doors are opened for examination.

Barber's Chair.—Deck fixtures; two or more.

Berthing Spaces.—The deck fixtures to be so located as to clear mess tables when stowed or being handled. A liberal allowance of end room is required when located between the same beams as the tables. The *minimum number of standing lights* is that necessary to assure convenient travel from one compartment to another; locating at the side of the bulkhead doors favors the desired result.

Blacksmith Shop.—Deck lights overhead, keeping clear of the forge and the swing of the sledge around the anvil; also a switch-and-receptacle for a portable.

Blowers, Ventilation.—A switch-and-receptacle with a portable permanently installed and with a portable hook; for the examination of the lubrication, etc.

Blowers, Forced Draft.—A bulkhead or drop fixture so located as to show the operation of the header from which the bearings are oiled; also a switch-and-receptacle, with a portable permanently installed, with portable hook, for general examination of the working parts.

Boats, Davit, Cradle.—For the emergency handling of the boats at night, a switch-and-receptacle for deck lanterns on each side of the ship near each boat crane, if others are not already installed for intermittent use.

Book Cases.—In quarters, ceiling fixtures No. 1 or No. 3 located to throw the light at an angle of about 45 degrees. In other

locations than quarters, deck or bulkhead fixtures similarly disposed.

Booms, Boat.—A switch-and-receptacle on each side of the ship.

Booms, Propeller.—A switch-and-receptacle for each side. On ships of low freeboard an efficient location for the outlets is at the flagstaff. An elevation of three or four feet from the deck may be obtained by running the conduit up from below for a short distance above the stuffing tube and making a short horizontal run by using a nipple with two elbows; this may be used as a hinge piece for the upper extension to the switch-and-receptacles. The switch-and-receptacles are joined together in a vertical line by short nipples and mounted to a common base which is secured to the forward side of the flagstaff with ready means of detachment. When it is desired to lower the flagstaff in clearing ship for action the switch-and-receptacles are detached and lowered; the flagstaff can then be lowered independently. It is essential that the conduit be not located in the wake of the chocks for chains and hawsers where it will be carried away. The device is comprised in a standard drawing.

Booms, Coaling.—Switch-and-receptacles in the upper decks are required from which portables may be taken to afford light in coaling at night.

The searchlights are used at times to supplement the lighting in emergency; but their use is not recommended as in the inclined position of use the heating of the mirrors is excessive.

Bridges, Lower.—No fixed lights for general lighting are installed in these locations. There are especial requirements which are described under their specific headings.

Bulletin Boards.—A deck fixture located conveniently overhead.

Carpenter Shop.—Deck fixture overhead and a switch-and-receptacle for a portable.

Chart Board.—A switch-and-receptacle for a portable fixture such as a deck or battle lantern.

Coal Bunkers.—The lighting at the doors through which the coal is carried into the fire-room is by a bunker fixture so located as to throw the light on the coal which is in the immediate vicinity of the door.

The remaining lighting is done by similar fixtures located well to the top of the bunkers, and in a line with the escape doors or deck plates of the coaling trunks and thus light the last portions

of the bunkers when trimming; and by the overhead type of fixture.

Contagion Ward.—Ceiling fixture No. 3 overhead, and a double switch-and-receptacle for portable fixtures when making examinations.

Cranes, Boat or Anchor.—For the handling of the boats or anchors at night, switch-and-receptacles for deck lanterns on each side of the ship to be near each boat crane, if not already installed for the intermittent purposes; on the forecastle, to be conveniently located for use in securing or letting go the anchor, or for lowering over the side.

Coffer Dams.—Switch-and-receptacles for portables to be used as required if not already installed for other intermittent purposes.

Conning Tower.—A switch-and-receptacle and a battle lantern bracket for the battle lantern.

Conning-Tower Tubes.—When the tube is of sufficient diameter to be used as a means of access to the conning tower from below, bulkhead fixtures should be installed.

Coal Chutes and Trunks.—In some cases it is advisable to install bunker lights in the coaling trunks to assist in examinations to avoid choking up when coaling.

Coal-Trimming Doors.—Switch-and-receptacles for portables as required, if not already installed for other intermittent purposes.

Dispensary.—A ceiling fixture No. 3 and a deck light overhead; also a double receptacle for a desk light and fan.

Distribution Boards.—Deck fixtures, if not fitted with brackets as part of the construction.

Double Bottoms.—All man-holes on the hold deck, for access to the double bottoms, should be provided with switch-and-receptacles at the nearest convenient points on the hold deck for the connection of water-tight portables and portable ventilating sets.

Fresh-Water Tanks.—Deck and bulkhead fixtures as are required for handling of the valves, and switch-and-receptacles for portables for use in examination and cleaning.

Galleys; Admiral's, Captain's, Wardroom, and Crew's.—The deck fixture is ordinarily installed as giving the best general distribution of light. The heat, steam, and smoke pipes in these locations necessitate especial care in locating.

Gangway.—Switch-and-receptacles for the attachment of cargo reflectors or deck lights, which are used in lighting the side lad-

ders, etc., are installed; they are usually located in the hammock berthing.

Guns.—Conveniently to all guns are located switch-and-receptacles, and battle lantern brackets or stands for the battle lanterns. The switch-and-receptacles are located, if practicable, back of the breech of the gun, in order that the bight of the double conductor, plain, cannot foul the feet of the gun's crew at their stations. Battle lantern stands are installed in locations where there are no stanchions or bulkheads for the convenient attachment of the switch-and-receptacle and battle lantern bracket for cage mounts.

Hammock Stowage.—The normal lighting for other purposes is sufficient for the requirements in handling the hammocks.

Hatches, Companion.—A deck light over the foot of the ladders affords the best method of lighting; the shadow cast by the lower coaming shades the eye from the direct glare of the light when coming down.

Hatches, Boiler, and Engine.—The ladders and gratings used for access to the boiler and engine rooms can be best lighted by bulkhead fixtures and should avoid throwing a direct glare of the light into the eyes.

Hold.—When fitted with permanent ladders, deck fixtures are fitted in those parts of the hold which are ordinarily free from stowage; switch-and-receptacles are installed for the attachment of portables for locating and breaking out material.

Laundry.—Owing to the steam and dampness in this compartment the appliances are all of the water-tight character; deck fixtures overhead, and switch-and-receptacles for a water-tight portable for general use and examination of the laundry machinery.

Library, Crews.—(See Book Cases, last paragraph.)

Locker, Chain.—A switch-and-receptacle for a portable, located conveniently near the hatch.

Locker, Vegetable.—These lockers, when stowed on bridges and upper decks, can ordinarily be served from other switch-and-receptacles installed near by.

Locker, Wine.—A deck fixture in the nearest passages, controlled by a switch adjacent to the door.

Log Desk.—The lighting is furnished from a bulkhead fixture placed about one foot above the top of the desk.

Lucky Bag.—A switch-and-receptacle for the use of a portable, located conveniently near to the hatch.

Magazines.—The regular lighting of magazines is by magazine lanterns located in the magazine light boxes, and connected to receptacles which are also located in the light box. The reflectors in the lanterns are arranged with reference to the number of deadlights in the light boxes. In some cases it is necessary to increase the height of the lanterns by blocking up in the boxes in order that the light may be thrown towards the floor rather than horizontally or up.

The light boxes are of two types: One in which the magazine deck light box is inserted through the deck above, and one in which the magazine light box is inserted in the bulkhead.

Masts.—In military masts fitted with ladders for access to tops and where the lower parts, on the level of the bridges or chart house, are used for the location of wiring appliances, it is necessary to install bulkhead fixtures as may be required, and also switch-and-receptacles for a portable to be used when housing the topmasts.

Mess Tables.—The arrangement of overhead lighting should be made to include at least one deck light nearly over each mess table.

Motor-Control Panels.—The location of lights in the adjoining space should be so arranged that the proper amount of light is furnished for the operation of the panel and for replacing of fuses as required.

Offices (Admiral's Captain's, Executive Officer's, Paymaster's, Navigator's, Ordnance Officer's, Printing).—For standing desks. ceiling fixtures No. 3 are installed; for roll-top desks, the desk light with desk light hooks, suitably located.

Pantries (Admiral's, Captain's Wardroom, Junior Officers', Warrant Officers').—The overhead lighting is from deck light fixtures; a switch-and-receptacle is installed for a N. W. T. portable, for use in cleaning those locations not directly lighted.

Prison.—A deck light inside, with a switch outside of, and adjacent to the location.

Quarters, Warrant Officers'.—Ceiling fixtures No. 3 are used for overhead lighting.

Quarters, Petty Officers'.—Ceiling fixtures No. 3 to be installed for general lighting. Two or more desk lights as required.

Racks, Life Preserver.—The arrangement of lights on the

decks on which the life preservers are stowed should include the necessary amount of light to afford access to them.

Range Finder.—A switch-and-receptacle for a portable, for use in reading the scale, provided none are supplied for guns in the same military top.

Riding Bitts.—The portable for the anchor crane will usually suffice.

Room, Ammunition-Passing.—Deck fixtures overhead similar to ammunition passages.

Room, Band.—Deck fixtures overhead similar to armory.

Rooms, Bath (Admiral's, Captain's, Wardroom, Junior Officers' and Warrant Officers').—Deck lights overhead and a switch-and-receptacle for use in cleaning. When partitions are installed the even lighting of the compartments may be facilitated by placing the fixture over the divisions provided the remaining space above the division will admit of the ready removal of the guard and globe.

Rooms, Blower.—Deck fixtures located with reference to the best general service and a switch-and-receptacle for a portable for local examination.

Rooms, Bread-Mixing.—Deck fixtures overhead, located to shine in the bread troughs.

Rooms, Cleaning Gear.—Deck fixtures located so as to be uninjured by the handling of the gear.

Room, Cold-Storage.—Switch-and-receptacles for portables in the passage leading to the doors.

Room, Communication.—Deck lights overhead and a switch-and-receptacle for a portable.

Room, Draughting.—Ceiling fixtures No. 3 for general lighting and a desk light for each desk or drawing table.

Room, Drying.—Deck and bulkhead fixtures as required.

Room, Dynamo.—The lamps on the head boards of the dynamos, excepting in small rooms, are not considered as contributing materially to the lighting. The direct lighting of switchboard instruments is furnished by brackets attached to their panels, the supply from any separate generating set inside of its circuit breaker being provided in a panel.

For each generating set there should be installed a switch-and-receptacle for a portable to be used in examination or repair. One

of these will also be available for use back of the switchboard in cleaning, adjustment or repair.

The workbench, log desk, gage board, clock, thermometer, oil filters, etc., also require lighting.

The following are occasionally installed in dynamo-rooms and in these cases must be provided for: Action-cut-out switches, battery lockers, battery transfer switches, oil tanks, and lamp lockers.

When not practicable to install brackets at the rear side of the switchboard, bulkhead or drop lights are to be provided from the busbar circuit sufficient for all necessary examinations of the joints, etc., of the busbar and instrument connections.

In addition to these lights the distribution should be on a liberal basis for the cleaning, examination, use and repair of: Steam separator, steam traps, reducing valve, steam valves, exhaust valves, generating sets, switchboard switches, switchboard fuses, circuit breakers, shunt rheostats, ventilating motors if installed, ammunition shunts if installed, searchlight rheostats, annunciators, voice tubes and rotary transformers.

Room, Evaporator.—Bulkhead or drop lights as required for the pressure gages and water columns; deck or bulkhead lights for general lighting in removal of heaters; and switch-and-receptacle for use in examining and cleaning the interior of the evaporator.

Room, Fixed-Ammunition.—When required for constructional reasons, as in destroyers and gunboats the magazine lantern (a fixture secured to a bulkhead) should be used. Otherwise the regular light boxes to contain the magazine lantern.

The locations depend entirely upon and follow after the stowage of the ammunition.

Rooms, Engine.—The lighting of the main engine rooms requires most careful consideration as probably in no other part of the ship are there a greater number of details for which highly efficient lighting must be supplied, in order that the necessary supervision over the lubrication and action of the moving parts of the machinery may be facilitated. As far as practicable fixed lights should be used, and the movable lights generally restricted to accessory purposes and inner bottoms. Movable lights in engine and fire-rooms are the most frequent causes of grounds.

Very satisfactory results have been obtained with from 400 to

600 cubic feet of volume of engine-room compartment, to one 16-candle-power fixed light; each detail, however, requires individual consideration and the usual appliances may be enumerated as follows:

Engine Rooms.

Water service.
Engine turning.
Oil feeds.
Oil tanks.
Starting gear.
Gage board.
Bunker lights.
Condenser, main.
Condenser, auxiliary.
Bunker escape doors.
Air locks.
Platforms.
Indicator cocks.
Voice tubes.
Indicators.
Inner bottoms.
Fire and bilge pumps, main.
Fire and bilge pumps, auxiliary.
Circulating pump, main.
Circulating pump, auxiliary.
Feed pump, main.
Feed pump, auxiliary.
Shaft pump, for bilges.
Air pump, main.
Air pump, auxiliary.
Bunker portables.
Ladders.
Gangways.
Annunciators.
Telegraphs.
Manifolds.

Boiler Rooms.

Gages.
Blowers.
Manifolds.
Bunker Escape Doors.
Annunciators.
Passages.
Ladders.
Columns.
Inner blowers.
Bunker lights.
Bunker portables.
Voice tubes.
Air locks.
Platforms.

Gangways.—Whenever practicable, the conduit to the cylinder and steam-chest light should be from overhead to avoid the effect of the vibration of the engine.

One arc lamp is provided for each fire-room and two arc lamps for each engine room, as may be practicable in the space available.

Room, Handling, Turret.—The lighting to be based on 500 cubic feet of space to each 16-candle-power fixed lamp. The location of the lights to be preferably overhead. Two switch-and-re-

ceptacles to be installed with portables for the examination of the gear.

Room, Ice-Machine.—Deck, drop or bulkhead lights are required for the operation of the lubricating devices, pressure-gauges, working parts of the machine and the ice-working appliances. A switch-and-receptacle for a portable for each machine.

Room, Lamp (oil).—One bulkhead or deck fixture for general lighting.

Room, Oil.—A switch-and-receptacle, located outside, for the use of a water-tight portable.

Room, Operating.—A cargo reflector or 5-light reflector over each operating table to be supplied from a switch-and-receptacle, in the one case, or permanently installed in the other. Also two switch-and-receptacles for portables for each operating table.

Room, Paint-Mixing.—General lighting by deck fixtures. A switch-and-receptacle for portable.

Room, Issuing.—General lighting by deck fixtures. Two switch-and-receptacles, one for a desk light at desk and one for a portable for use in shelves and lockers.

Room, Reception, Admiral's.—The lighting to be on a basis of 500 cubic feet of space to each 16-candle-power in fixed overhead lights. Ceiling fixtures for overhead lighting. Brackets for lights on bulkhead, etc.

Room, Refrigerating.—Same as Cold Storage.

Room, Shell.—Same as Magazines.

Stateroom for Admiral, Captain, Chief of Staff, Personal Staff.—Overhead lighting by ceiling fixtures No. 1 or No. 3. A double receptacle for desk light and bracket fans.

Staterooms for Wardroom Officers, Junior Officers, and Warrant Officers, a double receptacle for desk light and bracket fan, and one commercial ceiling fixture overhead.

For chief petty officers, master-at-arms, and sergeant of marines a switch-and-receptacle for desk light.

In all the foregoing staterooms desk light hooks and cup hooks are installed according to the requirements of the locations in order to afford the greatest facility in the use of the lights at various parts of the rooms, for reading, writing, shaving, etc.

Room, Wirless-Telegraph.—A desk fixture overhead for general lighting and a switch-and-receptacle for desk light for use

in keeping log and examinations of appliances if required. All circuits to be in conduit to prevent reduction from the ærial.

Searchlight Platforms.—A switch-and-receptacle for battle lantern for use in replacing carbons, etc.

Shop, General Work.—The lighting to be on a liberal basis approaching 500 cubic feet of space to each 16-candle-power fixed lamp.

Each machine tool to be provided with a switch-and-receptacle for portable so spaced that all can be operated simultaneously.

Shower Baths (Officers', Petty Officers', Machinists', Crew, Freemen, and Servants).—Deck lights overhead.

Sick Bay.—A standing bulkhead light located with reference to affording only sufficient light for passage purposes at night.

Overhead lighting to be from deck fixtures. Double receptacles for portables for use in examining, taking temperatures of, and administering medicine to patients and also for bracket fans. A switch-and-receptacle for desk lights at desk.

When electric heaters are supplied, outlets for them are provided.

Side Ladders.—See Gangways.

Sighting Hoods.—In each sighting hood of the turret is installed a turret-hood fixture.

Signal Tower.—A switch-and-receptacle for a battle lantern.

Sounding Machine.—A switch-and-receptacle for a deck lantern.

Sounding Rods and Tubes.—No special lighting is required.

Scuttle Butt.—The deck or bulkhead lights in the vicinity will ordinarily suffice.

Scuttle Escape Doors.—See Bunkers.

Scuttle, Ammunition-Passing.—A switch-and-receptacle to be located near by for the use of a battle lantern.

Seamen's Head.—Deck fixtures for general lighting, and a switch-and-receptacle for use of portable in cleaning.

Shaft Alley.—A deck or bulkhead light at each bearing and located for the examination of the action of the lubricating devices. Two switches-and-receptacles in each compartment for use in cleaning and repair.

Steering Compartment.—Deck and bulkhead lights as required on a basis of 500 cubic feet to each 16-candle-power fixed light in the vicinity of the engine and gear; the indicators, dials, and lubri-

cating devices being specially provided for. A switch-and-receptacle for a portable to be located on each side.

Storerooms.—A switch-and-receptacle for a portable to be installed outside of the following storerooms, usually one portable for each two adjacent store rooms:

Admiral.
Bread room.
Chief petty officers'.
Construction.
Equipment.
General.
Battalion outfits and equipments.
Machinery.
Ordnance.
Sails.
Yeoman.
Captain.
Commissary.
Clothing and small stores.
Dry provisions.
Electrical.
Medical.
Junior officers'.
Marines'.
Paints and oils.
Warrant officers'.

Submarine Mines.—Same as Magazines.

Tiller Room.—Deck or bulkhead fixtures as required to examine the action of the lubricating devices; and a switch-and-receptacle for a portable for use when shipping and unshipping the spare tiller.

Admiral's and Captain's Dining-room, Wardroom, Messroom.—Ceiling fixtures No. 1 for overhead lighting on the basis of 400 cubic feet to each 16-candle-power fixed light; in order to give good lighting over the table, two of the overhead lights so determined should be either 3-light or 4-light electroliers or to be one in the center as necessary. Double bracket fixtures, at least two should be installed for side lighting, and a single bracket fixture placed over each side of the sideboard. At least two outlets should be installed for desk lights to be used as reading lights on the tables.

Wardroom Country.—Ceiling fixtures No. 1.

Washrooms (Petty Officers', Machinists', Firemen, and Servants').—Deck fixtures or bulkhead fixtures as required and a switch-and-receptacle for portable for use in cleaning.

Table, Chart.—A switch-and-receptacle for desk light.

Table, Mess.—See Wardroom, Messroom.

Tanks, Fresh-Water.—A switch-and-receptacle for portable,

located conveniently to the man-hole, to be used when inspecting and cleaning.

Tanks, Trimming.—A switch-and-receptacle for portable located conveniently to the man-holes.

Tops, Military, Upper and Lower.—Switch-and-receptacles for battle lanterns for use of guns, range finder, etc.

Torpedo-Rooms.—Deck and bulkhead fixtures as required on a basis of 500 cubic feet to each 16-candle-power fixed light. A switch-and-receptacle for a portable at each under-water torpedo tube.

Trunks, Ammunition.—No outlets.

Trunks, Coaling.—No outlets.

Turrets.—Switches-and-receptacles for battle lantern at rammer, elevator, and training-motor controllers.

The dial of the angle of train indicator to be lighted by a fixed 5-candle-power lamp fitted with a screen. (See also Sighting Hoods.)

Up Takes.—Bulkhead or deck fixtures as required.

Urinals (Officers', Crew, Firemen).—Deck or bulkhead fixtures as required and a switch-and-receptacle for portable in cleaning.

Water Closets (Admiral's, Captain's, Chief of Staff, Officers').—Ceiling fixtures No. 1 and a switch-and-receptacle for cleaning.

Water Closets (Petty Officers' and Machinists').—Deck fixtures and a switch-and-receptacle for cleaning.

Winches, Deck and Coaling.—Bulkhead or deck fixtures or adjacent bulkheads, stanchions or boat-stowage frames; located with reference to good lighting on the drums and controlling devices. A switch-and-receptacle for deck lantern for each winch.

Windlass, Enclosure, and House.—Deck or bulkhead fixtures on each side and as required at the controlling devices. A switch-and-receptacle for portable for general use.

Determination of the Motor Load.

Unlike the lighting load, the motor load is simplified by the absorption of a large proportion of energy and the apparatus is located with reference to convenience and use; and its determination can be readily made as in the table facing page 1204.

Determination of Interior Communication and Signal Load.

The division and amount of the energy required for interior

communication is evidently derivable from that required for the various devices which it has been planned to use.

The energy for signal use is computed in the lighting load.

Tabulation of Outlets.

The position of the various outlets for lighting, motor and interior communication use are next entered on the plans, by appropriate symbols, from which an exact tabulation is made on printed forms. From these plans and forms the various outlets are then grouped collectively on the submain, main, and feeder.

Laying Out the Wiring Plan.

The well-developed grouping of the load on submains, mains, and feeders, considering the economics of the case and the many conflicting and intervening continuances of construction of a ship's details requires experience and the draughtsman's art, but is developed along certain specified lines and rules of practice, the essentials of which follow.

Feeders.—Feeders are those lines of wiring which connect directly to the switchboard, and are divided into three general classes: Feeders for lighting circuits, feeders for motor circuits, and searchlight feeders.

Lighting Circuits.—No feeder is to have a greater carrying capacity than 75 amperes, this to be on a basis of 0.5 of an ampere for 16-candle-power incandescent lamps or 1/12-horsepower fans, and 1 ampere for 32-candle-power incandescent lamps or ⅙-horsepower fans.

The feeders are classed in two sub-divisions, *feeders for lighting service* and *feeders for battle service*. The lighting service feeders must evidently be sufficient to carry the entire full-connected lighting load of the ship and all desk and bracket fans, exclusive of that for battle service. The battle service feeders are separate and carry only that lighting load which will be used in action, day or night, and, therefore, the disposition of switches on the switchboard should assure that no unauthorized lighting can be fed by the battle service. The authorized lighting for a battle service is to include every light installed below the protective deck and all lights above the protective deck whose use are necessary while the ship is in action; this includes lights for operation of guns; at ammunition hoists; at boat cranes; at controllers;

in military tops; on searchlight platforms; in the conning tower; in the signal tower; in turrets; one or more of the lights in chart house and pilot house; all signal and running lights; binnacle lights; instrument lamps; at main blowers when they are located above the protective deck; and merely sufficient fixed lights to allow access to such passages and compartments as may be necessary in time of action.

Lighting service feeders are numbered and designated by the terms forward and aft, by decks or specific compartments, and are further divided into starboard and port as may be necessary to properly distinguish them.

An especial division of the lighting and battle service is the *Signal Circuit,* which requires a separate feeder and is installed to be connected to the battle circuit through a 50-ampere D. P. D. T. transfer switch. The circuit feeds outlets for chartboard, truck lights, wigwag, anchor lights, whistle operator, night signal, all telegraphs, pelorus, binnacles, peak lights, top lights, stern light, running light, towing light. (The running lights and towing light are installed on a conveniently located group switch and independent of all other lighting on the circuit.)

Arc lights should be installed on separate feeders; these feeders have a cross-section to give a current density of 1000 cm. per ampere at full-rated load, each arc light taking about 4 amperes.

Searchlight Circuits.—Each searchlight has a separate feeder leading from the searchlight distribution panel of the switchboard unless the searchlight and power panels are combined. The feeder leads through the rheostat, ammeter, and circuit breaker direct to the switch terminals located in the searchlight pedestal.

Motor Circuits.—Motors whose normal full-load working currents are less than 50 amperes may be grouped on the same feeder, but no such feeder is to have a load in excess of 100 amperes. Motors doing similar service in the same part of a ship are to be preferably grouped on the same feeder.

Each motor whose normal full-load working current exceeds 50 amperes is to have a separate feeder.

By using a suitable distribution board exception may be taken to above clauses in the case of turrets. Rammer, elevating, and ammunition hoist motors may then use the same feeder.

The area of the cross-section of the feeders for motors is to be

such that the fall in potential from the dynamo terminals to the motor terminals shall not exceed 5 per cent at rated full load; feeders and mains are at the same time to have a cross-section of not less than 1000 cm. per ampere for continuous service and not less than 500 cm. per ampere for intermittent service.

In general, mains lead from feeders through standard feeder junction boxes, having double-pole fuses of standard pattern. The feeder to enter at the end of the junction box, and not at the side. A switch to be installed in the mains to facilitate fusing.

When several mains lead from the same feeder at any one point an approved distributing panel with double-pole fuses of standard pattern for each main may be used. Standard fuses are to be installed.

Protection to Circuits.—It is mandatory in the case of all feeders that they be led below the protective deck or behind armor to the fullest practicable extent.

Inter-connecting Feeders.—The practice of inter-connecting feeders has been discontinued except in the case of those feeders which supply fire- and engine-room lighting. The method is to make a parallel connection for feeders, both forward and aft, on opposite sides of the ship, in order that should the feeders on one side be shot away the feeders on the other side will supply the lights pending repairs.

The mains are never to be used for inter-connecting feeders.

Mains.—The grouping of the lighting loads on submains or on mains requires especial ingenuity, as the main must show not only a convenient grouping for the location, but must also be entirely separate for the two classes of service, lighting, and battle. A preference is usually expressed for looping mains; that is, to have the ends of the positive leg connected together at the feeder and the ends of the negative leg similarly connected, each leg thus forming a closed circuit through the feeder on itself. The advantage is that the drops are better regulated for outlets fed by the main; the objection is that to ensure the advantage it is necessary to feed the loop at two points necessitating an extra feeder box and switch; the dividing line as to a preference is that when the load on the lighting circuit main exceeds 50 amperes a loop is better.

The distinctive term main rather presupposes a lesser office

than that of a feeder, but the distinction is mainly as to the type of junction box that may be used; a maximum carrying capacity of 75 amperes is as permissible in a single lighting circuit main as in a feeder; it should be noted in this connection that the side circuit carrying parts of the feeder junction box are designated for 60,000 cm. capacity and heating should be expected for currents over 60 amperes.

The connections of smaller motors to feeders are made through mains in accordance with the loads prescribed under feeders for motor circuits. They are rarely looped.

Submains.—These are the connections which conveniently group outlets to connect them to the mains which intervene between the submains and their supplying feeders, and consist of a positive and negative leg leading as directly as possible to and by the locations of the outlets. The general rule is the fewer the better.

When practicable, and to simplify wiring, these submains are avoided by making them of the same cross-section as the main and using a "solid" feeder box (unfused).

Branches.—Branches when for a single light, in conduit wiring, are of 4107 cm. twin conductor, and are run in ½-inch I. P. S. conduit. Circuits from distribution boxes to single outlets must be run with 4107 cm. twin conductor. Molding will not accommodate twin wire.

Determination of Wire Sizes.

From the laying out of the circuits the wiring is tabulated. From plan and elevation the length of wire required for the branches to each submain is measured; this gives the number of feet of 4107 cm. wire required. Next the length of the submain is measured; then the length of the mains; then the length of the feeders. In the tabulation is included the number of amperes for each outlet for the branch, submain, main, and feeder for the total connected load. Continuous feeders, or feeders connected to submains, as for motors, are tabulated the same way.

The allowance of circular mils cross-section wire is based on the following rules:

Lighting conductors are to have 1000 circular mils of area per ampere of current; but when by reason of length of run the cal-

culation by formula demands more than 1000 cm. per ampere the determination by the formula is to obtain.

The general formula for calculation of wire size is:

$$\text{C. M.} = \frac{A \times 2D \times 10.87}{d} \text{ in which:}$$

C. M. = Circular mils area.

A = Number of amperes of full-connected load.

$2D$ = The length of run back and forth (positive and negative legs), in feet.

10.87 = Resistance of copper at 95 per cent conductively for a temperature correction of the assumed average temperature plus 4 per cent for twist of wires in the strand (really a correction of D).

d = Drop in volts, between supply end and farthest outlet, calculated from the allowed percentage of the standard voltage.

The formula in its convenient form is $\frac{21.74AD}{d}$

The denominator is based on 3 per cent drop for lighting loads, and for motor input on continuous service (desk and bracket fans, portable pumps and dynamotors); and 5 per cent drop for motor input on intermittent services. The values of d in the two cases are: For 3 per cent, 2.4 volts for 80-volt supply and 3.75 volts for 125-volt; for 5 per cent, 4 volts for 80-volt supply and 6.25 volts for 125-volt.

Based on 1000 circular mils to the ampere, the length of run (from start to outlet) would be for the 3 per cent drop; for 80-volt circuit, 111 feet; 125-volt, 173 feet; for 5 per cent drop the length would be: 80-volt, 185 feet; 125-volt, 290 feet. These are the greatest linear distances to which the specification of 1000 cm. per ampere could be applied; greater distances must be calculated, the option to rest always with the method given of selecting the nearest standard conductor which will give the carrying capacity.

Inter-connecting feeders are to be calculated for a cross-sectional area of 1500 cm. per ampere.

Feeders and mains on motor circuits are to have a cross-sectional area of not less than 1000 cm. per ampere for continuous

service, and not less than 500 cm. per amperes for intermittent service.

The calculation for cross-sectional area of any feeder, main and submain is to be based on its total full-connected load.

The calculations are ordinarily provided for beforehand by the construction of a wiring chart, constructed for the two variables of length of circuit and ampereage; from this chart the wire size can be conveniently picked off.

Fuses.

Every reduction in the size of a feeder or main is fused. Fuses for feeders and mains are to be at the rate of 1 ampere per 1000 cm., and to blow at the rate of 1 ampere per 500 cm.

Whenever mains are led off from feeders it is done through standard feeder junction boxes, having double-pole fuses of standard pattern, and to blow on the basis of 1 ampere per 500 cm. of the main.

All outlets are fed from mains by branch wires properly fused.

Fuses for junction boxes are to be for the normal rating of 3 amperes and to blow at 6 amperes for 125 volts, and for the normal rating of 4 amperes and to blow at 8 amperes for 80 volts.

Switches.

The feeders are controlled by switches and fuses or circuit breakers on the switchboard.

Switches are provided on all mains close to a feeder box, to facilitate re-fusing; in the case of looped mains they are placed near both junctions with the feeder.

In every case of a fixed outlet a switch is installed in a location of convenient access.

Contract Specifications.

The plans for the electric installations on contract ships are laid out at the Navy Department.

The "General Contract Specifications," that is, those which are printed in book form and including also the specifications for the vessel and the ordnance outfit, are necessarily incomplete (being prepared before many of the details of the ship are finally settled) but give the general scope of the installation.

As soon afterward as may be practicable more detailed plans are worked up and the locations of the various appliances for generation, control, lighting, signalling, power and interior communication are more accurately determined; from these a detailed specification is issued.

A General Guide to Installation Work.

The standard practice in installing the various details of the electric plant, excepting as to such details of the lighting, etc., as have already been referred to, is comprised in the following:

Dynamo-Room.—In all cases where practicable a separate compartment for the sole use of the generating sets and accessories is provided. It is to be located underneath the protective decks in all ships so fitted. In all other cases it is located with reference to the best attainable protection offered by coal and the water-line.

The dimensions of the room should be such as will allow a working space for the generating sets and accessories installed, not less than as follows:

(a) Between the edges of the foundations for one generating set, on the operating side, and the clear adjacent bulkhead or generating set foundation, a minimum distance of three feet.

(b) Between the edge of the foundation for one generating set, on the rear side, and the clear adjacent bulkhead or generating set foundation, a minimum distance of two feet.

(c) Between the flywheel, or edge of foundation of generating set, if the flywheel projects beyond it, and the clear adjacent bulkhead the distance not to be less than one foot in excess of the distance required by the change in position of the flywheel and that required by the flywheel disconnecting device.

(d) Between the edge of the foundation, on the armature end, and the clear adjacent bulkhead, a distance of not less than six inches in excess of the length of the armature shaft of the largest set installed in line.

(e) The intent of these separating distances is to provide a clear passage around each generating set, sufficient for all necessary operation and repair.

(f) Between the foundation of any generating set installed, and the face of the switchboard, a minimum distance of four feet.

(g) Between the back of the switchboard and the clear adjacent bulkhead a minimum distance of three feet.

(h) A clear access around each end of the switchboard to be of a minimum width of two feet.

(i) The workbench, oil tanks, and spare armature (if stowed in dynamo-room) to be not less than 3 feet from the foundation of the nearest generating set.

(j) Between the top of the cylinder and the clear lower edge of any beam over the piston or valve spaces to be not less than three inches more than the extra room required to remove the pistons or valves.

Generating Sets.—The shaft lines are, when practicable, to be fore and aft, in order to reduce the thrust on bearings when the vessel is rolling.

The sets are located, with reference to their cylinders, so that the deck beams shall not interfere with the removal of pistons and valves.

Each set where furnished in lots of two or more for the same ship is fitted with a metal name plate with figures one inch to two inches high attached to a prominent place, visible when standing facing the commutator, for designating the serial set numbers 1, 2, 3, 4, etc.

The numbering of the sets begins with the forward, starboard, upper set, and continues across the ship consecutively; and then below or aft, according to the location of the dynamo-room.

The bed-plate of the generating set is fitted with brackets for a starting bar.

Stout brass oil guards, capable of ready removal, are fitted, if necessary, to prevent oil being thrown from engine. Brass hand rails are to be provided, attached to and extending around, each generating set, and mounted on the edge of the foundation.

Foundations.—The deck under all generating sets should be primarily so supported and strengthened that it will easily sustain the weight, and ensure that the framing of the vessel will assist in securing rigidity and preventing vibration of the set.

All bed pans are levelled fore and aft and athwartships and consist preferably of a metal pan, with edges turned up about two inches to catch waste oil and water; the pan to rest on and be secured to a wooden layer not less than two inches in thickness,

to deaden vibration. The wooden layer is in turn supported by a metal plate, or channel or *Z* bars secured to the deck.

The usual foundation is shown in cross-section in Fig. 286.

[NOTE 33.—The foundation just described is found insufficient for the purpose for generating sets of larger size than 32 k. w., especially with raised cylinders, the reason being that the usual ⅜-inch deck (even with strong framing) and the wood filling does not prevent deleterious vibration.

The latest plan for the large sets is to overlay the ⅜-inch deck with a solid plate, one inch in thickness (40 pound plate) and bring the bed-plate of the generating set down flush to this heavy plate. As the generator frame extends below the base of the bed-plate, provision is made by cutting out and fitting in a light pan with a drip cock for draining. The wood is omitted when adopting this plan of foundation.]

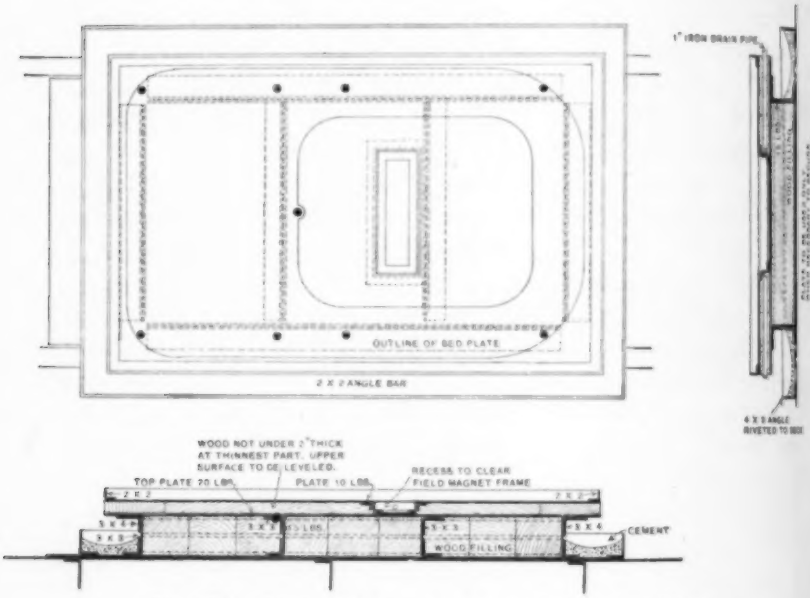

OUTLINE OF BED PLATE
2 X 2 ANGLE BAR
WOOD NOT UNDER 2" THICK AT THINNEST PART. UPPER SURFACE TO BE LEVELED.
TOP PLATE 20 LBS.
PLATE 10 LBS.
RECESS TO CLEAR FIELD MAGNET FRAME
CEMENT
WOOD FILLING

FIG. 286.—Cross-section and plan of usual foundation.

Main Steam Pipe.—This is fitted with a stop-valve, reducing valve, and separator all located in the dynamo-room unless otherwise specified. In no case should it be connected with any engines but those of the generating sets. It is tapped for connections with the steam gauge at each side of the reducing valve.

The dynamo engines are usually provided with steam supply pipes from the port and starboard steam lines or auxiliary boilers,

these pipes being cross-connected in the fire-room. Stop-valves are placed in each supply pipe between connection and the boilers in order that steam may be taken from the port boilers, while the starboard boiler valves are being overhauled and *vice versa*.

Separate Condenser.—The latest and best practice in larger vessels is to install a separate condenser in the dynamo-room, or in an adjacent compartment for the sole use of the dynamo engines.

Main Exhaust Pipe.—This is fitted with a stop-valve, placed where it will be accessible in the best position to insure minimum condensation in the branch exhausts, the exhaust pipes being led directly to the condenser. In no case should these be connected to a common auxiliary exhaust nor with the low pressure receiver of the main engines. The pipe is to be tapped for a combined vacuum and back pressure gauge. When a separate condenser is installed there should also be connections to the main and auxiliary condensers as well; this is sometimes overlooked.

Branch Steam and Exhaust Pipes.—The steam pipes are fitted with a stop-valve near the main pipes and the throttle at the engine.

Exhaust pipes are fitted with a stop-valve near the main pipe.

Joints.—No joint of steam, exhaust, water pipes, or fire mains should be placed over or in line with the dynamo, switchboard, rheostats, or other electrical apparatus which is liable to injury from leakage.

Leads of Piping.—All piping should be led with especial reference to head room and the facility for removal and repair of pistons and valves, and the attachment and use of the indicators.

Covering of Piping.—All pipes are covered with an approved non-conducting material and protected with canvas or metal.

Steam and Vacuum Gauges.—The two gauges on the steam pipe and the one on the exhaust pipe are mounted together on a back board, with an indication by marking on the dial or name plate as to their connection.

Separator.—A separator for at least each two dynamo engines installed should be provided; each to be of a capacity of eight times the volume of the high-pressure cylinder.

Reducer.—A reducer is installed if the rated pressure of the generating set is below that of the usual boiler pressure as shown by the dynamo-room gauge.

Traps.—These are to be of large capacity and so connected as to take the condensation of the separator. The drip pipes of the engines and drains from the lower ends of all piping to connect to the discharge side of the trap.

Dynamo-Room Fittings.—*Oil Tank.*—This should be located below the protective deck and in the dynamo-room if at all practicable. *The location should be well up to the overhead deck in order to provide a gravity supply, with facilities for draining and for filling from deck above; and be fitted with necessary piping and cocks for drawing off at each generator set. If a gravity supply is not practicable, a hand- or motor-driven pump should be provided for forcing the oil to each generating set.*

The oil tanks are provided with a name plate giving the capacity in gallons and also with an oil gage graduated to show the contents in gallons and a cock for cutting off that tank from the supply.

The tank capacity for a ship is based on the following for each generating set:

K. W. Capacity.	Allowance of Oil. Gals.
16	20
24	25
32	30
50	40
75	50
100	60

Oil Filters.—If space will admit, two filters are supplied for the dynamo-room.

K. W. Capacity of Sets in Room.	No.	FILTER. Capacity of each Filter. Gallons.
5	2	10
8	2	10
16	2	30
24	2	30
32	2	30
50	2	60
75	2	60
100	2	60

If the construction of the filter includes heating coils they are connected with the steam and drip main.

An oil set and oil set bracket is to be installed in each division of the dynamo room.

Save Alls.—These are for catching the waste oil from the drain pipe of the engine base. The following table gives standard sizes:

K. W. Capacity of Set.	Size.		
	Length. in.	Width. in.	Depth. in.
5 & 8	8	4	4
16	10	5	5
24	10	5	5
32	10	5	5
50	12	6	6
75	12	6	6
100	12	6	6

Waste Tank.—Two waste tanks are provided in each dynamo-room, one for the oily waste and the other for the clean waste; to be marked respectively *Dirty Waste* and *Clean Waste.*

They are of the following sizes:

Oily waste tank, 11¼ inches diameter, 15 inches high.

Clean waste tank, 20 inches by 15 inches by 20 inches high.

Workbench with Vise.—This is installed in the dynamo-room when practicable, and to have drawers beneath for stowage of tools.

Test Panel.—If practicable, this is installed near the workbench, for testing fuses, portables, lamps, etc.

Wrench and Tool Board.—These are conveniently placed near the workbench, and arranged for securing the tools in place.

Lifting and Transporting Devices.—These are not required for sets of and below 5 k. w. For heavier sets they may consist of two differential pulleys and a traveller. If no traveller is provided, eye bolts with links are fitted overhead as required for lifting any heavy part, and for transporting it to the hatch or door of the dynamo-room. The lifting capacity of the pulleys should be ample for handling the heaviest part that may be required to be moved in the dynamo-room.

Spare Armature Supports.—One set of supports installed for each size of generating set, in each dynamo-room. Duplicate sets are not required to be installed for adjacent dynamo-rooms.

Canvas Covers.—The spare armature is to be provided with a close-fitting, laced, khaki cover.

Log Desk.—This is located with reference to the switchboard and gages, if practicable, and is provided with a drawer large

enough to take rough sheets (11 inches by 18 inches) of the electrical journal.

A block fitted for the clock and psychrometer is secured over the log desk.

Lockers.—One of each dynamo-room is provided for stowage of such tools as are not placed on the tool board; and for the indicator, portable ammeter, portable voltmeter, testing generator, and tachometer.

Dynamo Leads.—The dynamo and equalizer leads have a cross-section on the basis of 1500 cm. per ampere of the rated capacity of the dynamo, and lead to the switchboard on porcelain insulators. Areas required in excess of standard size are obtained by paralleling smaller cables.

When three or more dynamos are to be connected to the same switchboard, the resistance of the equalizer leads must not vary more than 5 per cent from one another. To obtain this degree of equality of resistance where, owing to the relative locations of dynamos and switchboards there is an inequality of distance, the lead of the shorter one is lengthened by looping.

The arrangement of dynamo leads must be such as to ensure the equality of division of load in parallel operation in conformity with the requirement of 20 per cent in the specifications for generating sets. (See Paralleling, page 1122.)

Storerooms.—These are located near the dynamo-room and fitted with desk and workbench in case it has not been possible to locate the workbench in the dynamo-room.

Shelving and lockers are provided for the storage of spare parts of all motors installed, spare parts of generating sets, tools not ordinarily in use, parts of lighting fixtures, searchlight carbons, spare lamps, spare wire, fuses, battery supplies, the illuminating outfit and its spare parts and lamps, and portables not in use. A metal waste tank is installed having capacity to take the ship's allowance of waste, and so constructed that one side is removable in order that a whole bale of waste can be put in at a time.

Switchboard and Rheostats.—The location should be as high above the deck as convenience of access to the appliances and available space will permit; and to be placed clear of the dripping from valves, dead-lights, joints of steam, exhaust and water pipes, and fire mains, or condensation from ventilating or water pipes overhead.

The top edge of the switchboard should be not more than seven feet above the deck. It is to be installed with special reference to accessibility and protection against oil thrown by the moving parts of the generators and engines. A hand rail should be fitted across the front of the board.

Switchboard.—The switchboard leads coming up from below have the deck stuffing tubes or conduit to extend at least six inches above the deck, and rise up within six inches of the center line of the board.

The metal framing supporting the switchboard is to be rigidly secured to the deck at its lower part, and the upper part secured to the bulkhead or deck overhead in a manner that will allow a vertical displacement, in the event of the deck being injured, with a minimum of horizontal displacement.

Switchboards should also be fitted with suitable brackets for the switch levers and voltmeter plugs when not in use.

Shunt Rheostats.—These are so installed as to interfere the least possible with the accessibility to the bus connections; preferably at the top of the board, using, if required for this purpose, sprocket and chain connection.

Searchlight Rheostats.—The searchlight rheostats are located as conveniently near to the panel as space will admit, and are marked with the names corresponding to their respective lights. The resistance part may be separated from the control to facilitate installation and keep heat from instruments.

Running Lights, Signal Lanterns, Truck Lights, Night-Signal Set, Searchlights.—*Running lights, towing range, and top lights* are furnished with, and connected to, two lengths of double conductor, plain, and two receptacle plugs; the lengths of conductor being that best adapted for connection with the receptacles. Receptacles for the foregoing lights are placed conveniently near the lights and without switches. The junction boxes are to be easily accessible for replacing and inspecting fuses.

Signal lanterns are furnished with, and connected to, a length of double conductor, plain, and a receptacle plug; the length of conductor being that which is required for the especial use. The peak light cable and ladder are in accordance with standard drawing. Ordinarily four red, eight white, and three green signal lanterns are provided for each vessel.

Double-truck Lights.

Double-truck lights are installed on the fore and mainmasts of vessels having two or more masts. Single-masted vessels have a double-truck light on at that mast. Torpedo-boats and vessels of special design are not fitted with double-truck lights unless specially authorized. Double-truck lights are furnished with, and connected to, two lengths of double conductor, plain, and two receptacle plugs, the length of conductor being that best adapted for connection to the receptacles; the receptacles are without switches, and are located, in case of use with topmasts, on the bibbs or athwartship brackets of the military top; in the case of pole masts the receptacles are located under the upper deck in which the mast partners. Circuits from the controller to the receptacles are the standard No. 14 B. & S. G. conductor; in case of very long runs 9000 cm. is run if better adapted for the particular vessel.

Night-Signal Sets.

The signalling sets are connected to a 25-ampere switch-and-receptacle, installed on the signal circuit. The lower end of the lamp ladder of the night-signal set is steadied by a galvanized wire cable setting up with a turnbuckle and plate inboard.

The keyboard is located on the bridge where the operator can plainly see the lamps of the signal set, being well secured on the bridge rail or on a suitable pedestal, so that vbrations will not interfere with sending a message. A metal cover is fitted to protect the keyboard from the weather.

For convenience in estimating the conductor size and fuse capacity of the current supply, a standard tabulation is made for the running lights and signals, the navigational instruments and devices including mechanical telegraph lighting and for the night-signal set.

Interior-Communication Circuits.

These circuits are classified as follows:

Call bell circuits.
Telephone circuits.
Fire alarm circuits.
Magazine alarm circuits.
Warning signal circuits.
Battery control circuits.
Turret hoist indicator circuits.
Electric log indicator circuits.

General alarm circuits.
Water-tight door indicator circuits.
Helm angle indicator circuits.
Steering telegraph circuits.
Engine telegraph circuits.

Call Bell Circuits.—Call bell circuits comprise *the quarters and office calls* and *the voice tube calls.* Whenever it is necessary to prevent confusion in calls to the same general location or compartment an annunciator is installed, the number of drops being that convenient for the particular locality.

The actuating switch on call bell circuits is invariably the push button, which is of the non-water-tight type in quarters. In staterooms the push button should be located near the head of the berth. Push buttons at tables are of the pear push type, the cords leading from ceiling buttons; hooks are conveniently placed for hanging the bights of the cords. Push buttons for voice tubes are located, if practicable, directly over or under the mouthpiece.

Quarters and Office Calls.—The standard list of battleship calls comprise the following:

An annunciator with buzzer in the admiral's pantry, with push buttons at the following locations (14 drops):

Admiral's cabin at desk.
Admiral's cabin at transom.
Admiral's cabin over table (one double pear push).
Admiral's after cabin at transom.
Admiral's after cabin over table (one double pear push).
Admiral's reception room at transom.
Admiral's reception room over table (one double pear push).
Admiral's office.
Admiral's stateroom.
Admiral's bathroom.
Forward cabin.
Chief of staff's stateroom.
Chief of staff's bathroom.

Admiral's orderly annunciator with bell located on gun deck bulkhead, with drops for all the preceding calls, except admiral's bathroom and chief of staff's bathroom; also a drop for a call from the signal tower; altogether 12 drops.

Annunciator (8-drop) with buzzer in captain's pantry, with push buttons at the following locations:

Captain's cabin at desk.
Captain's cabin at transom.
Captain's cabin over table (one double pear push).
Captain's stateroom.
Captain's office.
Captain's bathroom.
Forward cabin.

Captain's orderly annunciator (8-drop) with buzzer at the gun deck bulkhead, with drop for the preceding calls, except from bathroom; also a drop call from quarterdeck.

Annunciator with buzzer in wardroom pantry with push buttons at the following locations (the number of drops will necessarily depend upon the number of staterooms):

Each wardroom stateroom.
Executive officer's office.
Navigator's office.
Ordnance officer's office.
Log room.
Paymaster's office.
Wardroom messroom over table (single pear push).
Wardroom messroom over table (double pear push).
Wardroom messroom starboard at transom.
Wardroom messroom at transom (port).
Wardroom country, at transom.
Wardroom bathroom (all push buttons on the same drop).

Annunciator with buzzer in junior officer's pantry with push buttons in the following locations (number of drops dependent upon the number of staterooms):

Each junior officer's stateroom.
Junior officer's messroom (all push buttons on same drop).
Junior officer's bathrooms (all push buttons on same drop).

Annunciator with buzzer in warrant officers' pantry with push buttons in the following locations (number of drops dependent on the number of staterooms):

Each warrant officer's stateroom.
Warrant officers' messroom (all push buttons on same drop).
Warrant officers' bathrooms (all push buttons on same drop).

Buzzer in yeoman's storeroom with push button in executive officer's office.

Annunciator with bell on quarter deck for messenger, with push buttons in executive officer's office, executive officer's stateroom, and to the double pear push over wardroom mess table.

Buzzer for navigator's writer with push button in navigator's stateroom.

Buzzer in paymaster's office with push button in paymaster's stateroom.

Buzzer in paymaster's issuing room with push button in paymaster's office.

Buzzer at first sergeant's desk with push buttons in marine officer's stateroom.

Bell for printer with push button in admiral's office.

Buzzer in electrical gunner's stateroom with button in navigator's stateroom.

A few other calls are installed as may be considered necessary from differences in ship construction.

Not more than one drop on any one annunciator are assigned to the same room or compartment for a similar purpose, but this one drop may be operated by several push buttons located in various places in the same room or compartment.

Boat Hour Gongs.—Push buttons on quarter deck operating the single stroke 5-inch gongs which are located as follows:

Gun deck.	Berth deck on barbette forward.
Berth deck on after bulkhead.	Berth deck on barbette aft.

Voice Tube Calls.—Voice tubes should not be installed when the length of tube will exceed 250 feet, and, as a rule, the length of any angle tube should be limited to a length of 200 feet.

Voice tubes to be 2 inches in diameter except in the cases below mentioned. For short, direct leads 1½-inch tubes are allowed as for ammunition hoists and ash hoists; for long lengths the 3-inch size is installed when and where directed. Attention is called in every case by bell. When there are two or more outlets an annunciator is installed. Return calls are installed at each end of continuous voice tubes, call to be made by bell, and not by whistle alone. Valves for branches are installed as directed.

The usual voice tubes installed in a battleship and which are of 2-inch size are:

Pilot house and conning tower to:

Steering engine room.
Both engine rooms.
Signal tower.
Observation platform.

Conning tower to:

Forward turret.
After turret.
Upper foretop.

Communication room to main deck, usually two tubes; a tube to each gun position on the gun deck, with two extra for the gun division; also a tube to both lower tops.

Starboard (or forward) distribution room board to:

Main deck.
Upper deck.
Forward handling room.
After handling room.
Forward projectors.
Foretop projector.
Passage, upper platform.
Port (or after) distribution board.
Starboard (or forward) dynamo-room.
Port (or after) dynamo-room.

Port (or after) distribution room board to:

The same stations as for the starboard (or forward) board, except to lead to the named locations for the after part of the ship and for the after searchlights.

Port engine room to each port fire-room.

Fire-rooms to each other, as follows:

Fire-room No. 1 to fire-room No. 2.
Fire-room No. 1 to fire-room No. 3.
Fire-room No. 2 to fire-room No. 4.
Fire-room No. 3 to fire-room No. 4.
Fire-room No. 3 to fire-room No. 5.
Fire-room No. 4 to fire-room No. 6.
Fire-room No. 5 to fire-room No. 6.
Fire-room No. 5 to fire-room No. 7.
Fire-room No. 6 to fire-room No. 8.
Fire-room No. 7 to fire-room No. 8.

From each ash hoist on the main deck to the location of ash heaps in the fire-room.

For each ammunition hoist from:

Point of delivery to loading location below.
Loading location to motor.

Gun deck, starboard and port, two tubes from selected locations

through the bulkhead; also two tubes from selected locations to the 6-inch guns on both sides of the main deck.

A voice tube is installed between the pilot house and the standard compass.

The following are generally installed in 3-inch tubes, with flaring mouth-piece: Pilot house to chart house; pilot house and conning tower to communication room and signal tower to communication room.

Notes on Voice Tubes.—Such of the voice pipes terminating in the communication room as may be considered necessary are continued up to the conning tower.

The voice pipes leading from the pilot house and conning tower to the starboard engine room, port engine room, signal tower and observation platform; and from the conning tower to the forward turret and after turret, are continuous through the conning tower to the pilot house and are fitted with 3-way valves. They have separate calls to each station.

All voice pipe mouths have an approved pattern, and, excepting in the conning tower and pilot house, leads to the engine rooms, whistles are installed. Voice pipe outlets are bell mouthed and fitted with hinged metal covers. The whistle is on the side of the bell and not on the hinged cover. Electrical calling apparatus with return calls is installed for each voice pipe outlet, excepting ammunition hoist and ash hoist tubes; the same annunciator bells and the like used in connection with the telephone calling system may be employed when available. Buzzers are used in all locations not subject to noise which might render the signal inaudible. Locations having but one voice pipe and one telephone call may be fitted with both a bell and a buzzer in lieu of an annunciator. Other locations having more than one call are fitted with a suitable annunciator operated in connection with a bell or buzzer, as the case may require.

Voice pipes in addition to the above list are installed as may be deemed necessary to render the system efficient and complete.

The efficiency of a long lead of voice tube being materially affcted by elbows and bends, it is essential that all leads be as direct as possible and free from any unnecessary bends and offsets. All necessary bends, offsets, and elbows are made by bending a piece of the voice pipe to the required shape, excluding to the greatest possible extent the use of separate elbows and the like.

Telephone Circuits.

[NOTE 34.—It is not practicable to derive from present installation practice any fixed rule for telephone circuits as the practice is one of continual change and will be much influenced by the determination of an efficient and acceptable system of fire control. It is a matter of grave doubt whether telephone communication can be relied upon in action, owing to the effect of gun shock upon the material of the microphone, whose particles invariably pack under that action. Up to the present the lines are led to a switchboard located in the communication room, the type of board being that derived from the ordinary board of commercial practice, and supplied by the Western Electric Company.]

Fire Alarm Circuits.

The annunciators are located in the dynamo-room unless otherwise directed. The thermostats are placed in metal cases over-

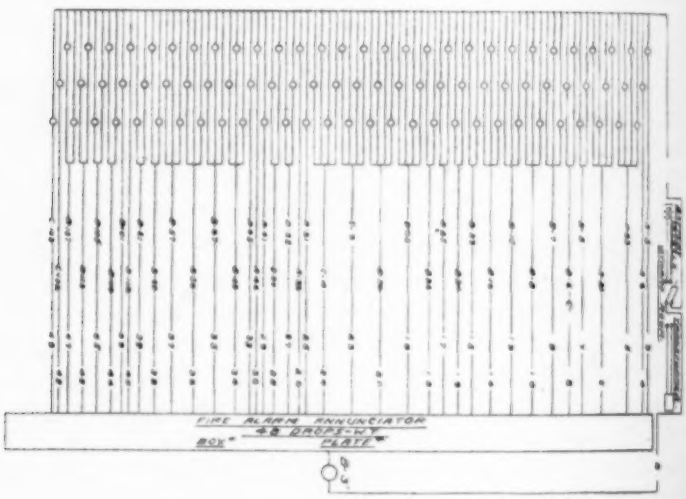


FIG. 287.—Fire alarm circuit diagram.

head in the storerooms and on bulkheads in all bunkers about three feet from the bottom of the bunkers, and in that part of the bunker which is most exposed to heat from the boilers.

All thermostats in any one compartment are connected in parallel, and coal bunker thermostats, magazine thermostats, and storeroom thermostats are indicated on separate annunciators.

Thermostats are installed in the following storerooms:

Construction.	Admiral's.
General.	Captain's.
Machinery.	Wardroom.
Commissary.	Junior officers'.
Equipment.	Warrant officers'.
Electrical.	Marine's.
Clothing and small stores.	Chief petty officers'.
Ordnance.	Paymaster's.
Infantry stores and equipments.	Miscellaneous storeroom.

A typical set of connections for one annunciator is shown in Fig. 287.

Magazine Alarm Circuits.

The circuits are distinct and separate from the fire alarms. The

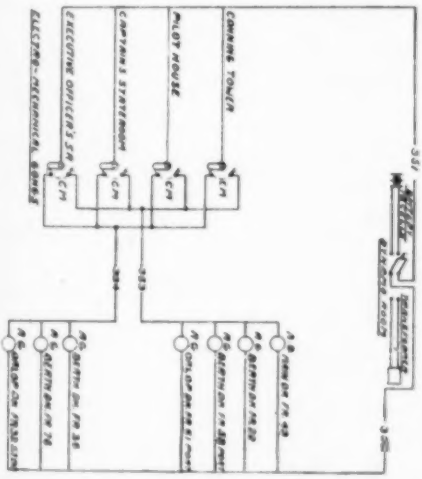


FIG. 288.—Diagram of general alarm circuit.

annunciator is installed in the dynamo-room. The thermostats are installed in magazines, shell rooms, torpedo-head rooms, submarine mine rooms, and as per plans.

The connections are similar to those for the general fire alarm circuits as shown in Fig. 287.

General Alarm Circuits.

The gongs are so located in the living and working spaces as to be heard by all the ship's force. The gongs are operated by push

buttons located in the chart house, conning tower, and the state-rooms for the captain and the executive officer. All push buttons for the general alarms in these locations are covered by a metal cover which will require removal prior to operation and thus prevent mistake. A typical set of connections is shown in Fig. 288.

Water-tight Door Indicator Circuit.

The indicators are installed in the chart house or on the bridge, their connection plan being a part of the specified arrangement of circuits for the water-tight door installation.

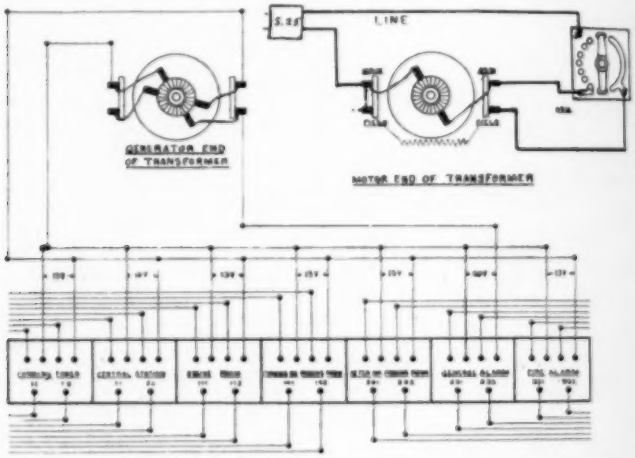


FIG. 289.—Diagram of warning signal circuit.

Warning Signal Circuit.

The shrill whistles are installed in sufficient number and so located as to be heard in all compartments below the protective deck, and in all other compartments in which the siren is not audible. The operating mechanism is installed on the bridge, in the pilot house, and such other places as may be directed.

A typical set of connections is shown in Fig. 289.

Fire Control Circuit.

As previously stated, the fire control system is still under experiment, and present installations under this head are not now standard.

Turret Hoist and Ready and Ammunition Car Position Indicator Circuit.

The combined signal and position indicators are shown in Fig. 290.

Hoist and Ready Signal.—When the car is ready for hoisting, the plunger switch *P* is pushed, lighting the lamp in the indicator at the hoisting station. As the car starts up, the spring *N* trips the catch *L*, releasing the plunger and extinguishing the lamp.

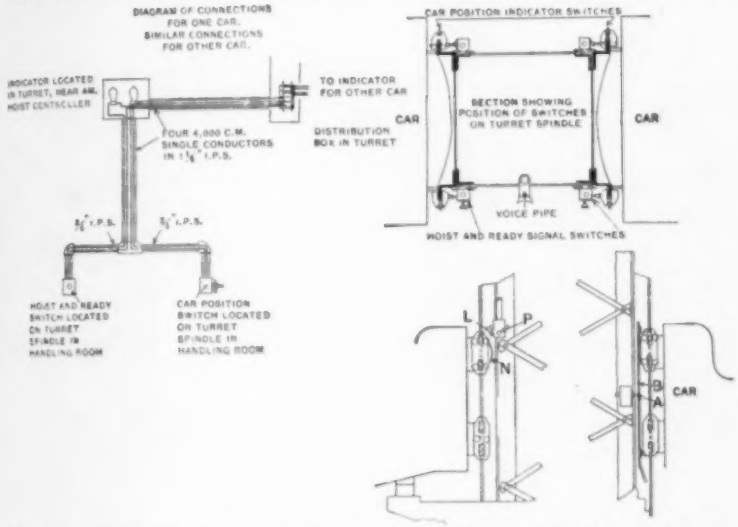


DIAGRAM OF CONNECTIONS FOR ONE CAR. SIMILAR CONNECTIONS FOR OTHER CAR.
INDICATOR LOCATED IN TURRET, NEAR AMM. HOIST CONTROLLER
TO INDICATOR FOR OTHER CAR
FOUR 4,000 C.M. SINGLE CONDUCTORS IN 1¼" I.P.S.
DISTRIBUTION BOX IN TURRET
¾" I.P.S.
¾" I.P.S.
HOIST AND READY SWITCH LOCATED ON TURRET SPINDLE IN HANDLING ROOM
CAR POSITION SWITCH LOCATED ON TURRET SPINDLE IN HANDLING ROOM
CAR POSITION INDICATOR SWITCHES
SECTION SHOWING POSITION OF SWITCHES ON TURRET SPINDLE
CAR
CAR
VOICE PIPE
HOIST AND READY SIGNAL SWITCHES
L
P
N
B
A
CAR

FIG. 290.—Hoist and ready signal and ammunition car position indicator.

Ammunition Car Position Indicator.—A phosphor bronze stop *B* is secured to the ammunition car; and the switch is secured to the track at such a height that, when the car is descending, and is 42 inches from the bottom, the strap will throw the lever of the switch *A*, thus closing that switch and holding it closed until the car reaches within 6 inches of the bottom of its travel; *on the upward journey the switch does not operate.*

In former installations the hoist and ready signal and the ammunition car position indication are separate.

Electric Log Indicator Circuit.

The bracket is located on a davit or stanchion on the quarter deck at each side with outlets convenient of access for the attachment of the transmitter.

The indicator is located in the chart house, and as a rule, but one is furnished.

The typical connections are shown in Fig. 284.

Helm Angle Indicator Circuit.

The contact arc is located in the tiller room. The indicators are located in the steering engine room, conning tower, chart house, on the bridge, and at the wheels aft. Standard action-out-

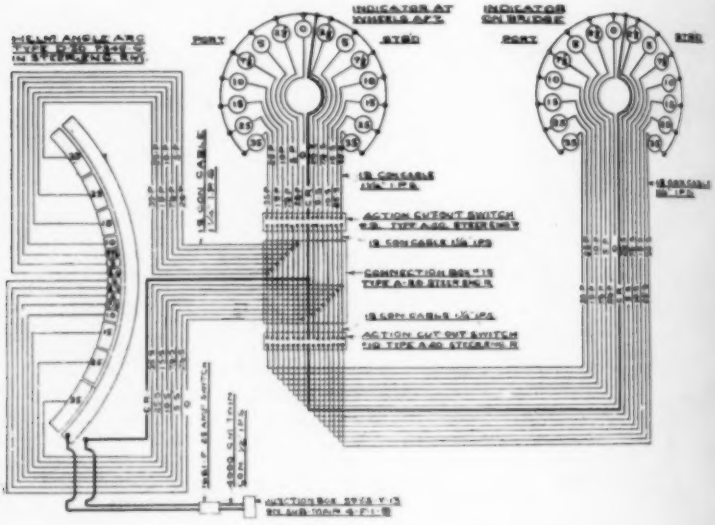


FIG. 291.—Diagram of helm angle indicator circuit.

out switches are placed on the circuits leading to the chart house, bridge, and wheels aft. A typical circuit connection is shown in Fig. 291.

Steering Telegraph Circuit.

The transmitters are located on the bridge, in the chart house, and in the conning tower. The receivers are located in the tiller room, steering engine room, and at the wheels aft. Standard action-out-out switches are placed on the circuits leading to the bridge, chart house, and the wheels aft.

The typical connections are shown in Fig. 292.

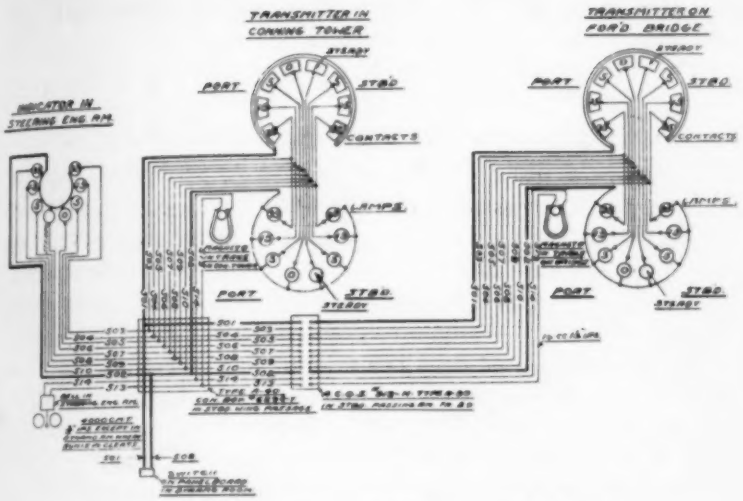


FIG. 292.—Diagram of circuit for steering telegraph.

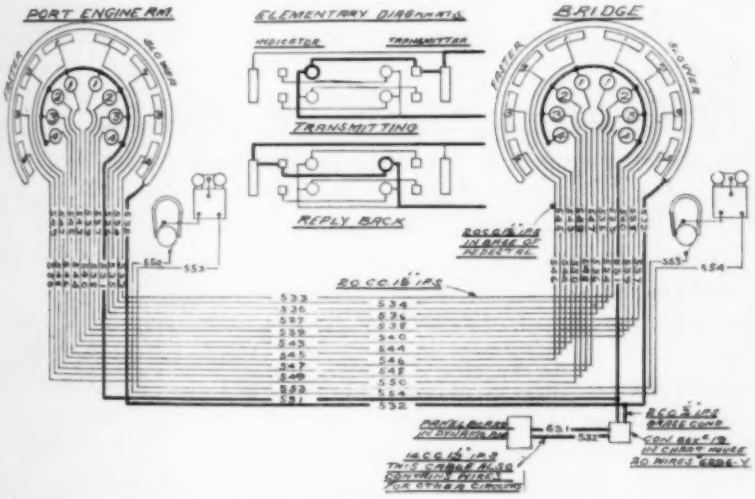


FIG. 293.—Diagram of engine telegraph circuit.

Engine Room Telegraph Circuit.

A combined transmitter and receiver are installed on both bridges (in chart house and conning tower if directed), with a combined receiver and transmitter in each engine room. If not

included in the transmitter, an audible signal is installed to call attention to the sending of an order.

The connections are shown in the diagram of Fig. 293.

Engine Revolution and Direction Indicator.

The transmitters are in the shaft passages; in vessels not provided with shaft passages (or alleys) they are located as far aft as possible. The receivers are located in the engine rooms, conning tower, and on both bridges. Standard action-out-out switches are placed on the circuits leading to the chart house and bridge.

The connections of the Cory type of instrument are shown in Fig. 265.

Panel for Telegraphs and Indicators.

There is installed in the dynamo-room a panel, with double fuses of standard pattern, for the supply of the current to the circuits for wireless telegraph, the rotary transformer for call bells, fire control, electric log indicator, helm angle indicator, steering telegraph, engine telegraph, and engine revolution indicator.

Notes on the Installation of Ducts, Conduit.

The primary and important consideration in the installing of conduit is that each separate line of conduit must be easily accessible for individual removal and repair. This injunction provides a large saving in cost and time for navy yard repairs, and is a vital matter for repairs and for replacing circuits during action; and, as running conduit through beams practicably defeats the intent, *any system of running conduit through beams should be prohibited.* It must be presumed that the beam has been designed to be as light, within the safety factor limits, as proper structural strength will admit and the slightly better appearance is not an excuse for vitiating strength. Again the conduit must be cut for the purpose, entailing extra time, cost, and the extra weight of unnecessary couplings. Drilling for hangers is objectionable even though far less pernicious, and clamping to the edge of the beam is the best practice as it is not only secure, but facilitates installing and removal. In quarters, however, it is often advantageous to run through beams, and the objection for the small piping does

not obtain. Here, as in superstructures, main and gun decks, advantage can be taken of running through lightening holes in the beam knees, being careful that each individual lead is accessible.

No cutting of stiffeners on bulkheads should be permitted except when it is absolutely necessary and only in special emergency. Ordinarily this can be avoided by blocking out the appliances from the bulkheads and connect through a hole through the bulkhead, inserting a nipple.

To facilitate access to the gland in the stuffing tubes a distance of about 4½ inches should be allowed above the top of the gland before the insertion of any union, coupling, or other appliance, in order that the gland may be lifted up.

Dixon's graphite grease is used to complete joints and must be put on all threads before securing into couplings, boxes, etc. Rubbing it on the outside of the joint is not sufficient as an alternative and is valueless as an additional operation. *Clean off any excess that may get to the interior of the conduit.*

A red lead cement is used under washers for joints at decks and bulkheads; it consists of 45 parts of white lead mixed in oil, and 15 parts of dry red lead.

For attaching to the deck beams and stiffeners, hangers are commonly employed which require drilling in the beam only; one is located at each beam, etc., unless the ordinary use of the location is such that there is no likelihood of any strain being put on the conduit, when one at each alternate beam is sufficient; if the hangers are of the sheet metal type they should not be closer together than a length of conduit unless made in small sections.

When the available space is restricted, the conduits may be more closely assembled by securing the hangers alternately to either side of the beam; these hangers are provided for use on angles, on double bulb beams and on single bulb beams, but care is to be taken with sheet metal hangers as in the preceding sentence.

Straps are used for fastening to bulkhead and other smooth surfaces. The metal used is iron for ordinary locations, and brass in locations where brass conduit is employed around binnacles or on wooden masts. The dimensions of the standard straps are such that the conduit is secured closely to the surface to which it is attached. A clearance being required for couplings, unions, etc., special straps are made as required.

In locations where the conduit is not likely to be subjected to any particular strain, such as in quarters, chart houses, etc., a lighter form of strap in both iron and brass is used. The ordinary spacing of straps is about 5 feet.

When fittings are, in themselves, bolted to the decks or bulkheads, this is considered as being equivalent to a strap and none is required immediately beyond the appliance.

When special straps are required under bolts of cylinder heads, steam chests, etc., special width iron is used as required by the diameters of the bolts.

Those conduit fittings which are not provided with methods of fastening are intended to be supported by the conduit, and straps should be installed near the appliance.

Good practice as to efficiency, cost and time dictates that all straight leads of conduit should be coupled together by screwing a length into the coupling of the last (each length having one coupling already screwed on when bought); when a wiring appliance is to be inserted a nipple must be screwed into the appliance, a coupling screwed on to this and then the next length of conduit screwed into this conduit. The appliance should be inserted at the end of a conduit length if practicable; if not, the conduit must be cut and threaded. When a bend must occur a union should be inserted in the line and the conduit cut to suit, *but under no circumstances should a "split coupling" be permitted anywhere on a conduit line, or any joint at a bend be made with a right and left handed coupling.*

Conduit and Conduit Fittings.

The types and various sizes are described under Wiring Appliances, and the following are, in general, their uses:

Brass enameled conduit is used wherever a run is to be made within 12 feet of binnacles, unless the compass is fully shielded by a steel deck or bulkhead; and for lengths through decks and bulkheads when exposed to salt water. When a bend is short, or a number of short bends are necessary, brass conduit is often useful by reason of its greater ductility. It is commonly used for truck-light or other circuits on wooden masts.

In all other cases *steel, enameled conduit* is used throughout.

Elbow, 90 degrees, with equal legs, are intended for all ordinary bends required.

Outlet elbows, 90 degrees, are only used in locations where it is absolutely necessary to make a shorter bend than can be done by the elbows, or for bends that cannot be made by the conduit bending machine.

Outlet elbows, 45 degrees, replace the outlet elbows, 90 degrees, in locations where two 45-degree elbows give a better bend than can be obtained by the 90-degree elbows.

Outlet elbows, 90 degrees, unequal legs, and long elbows, 90 degrees, unequal legs, are used similarly to the elbows, 90 degrees, with equal legs, but are better adapted to some locations when shorter radius of bend or length is necessary.

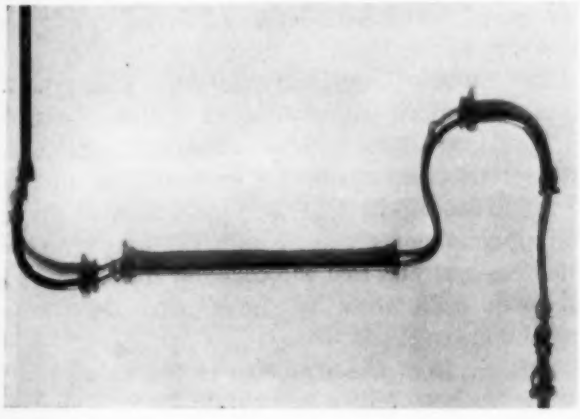


FIG. 294.—Sample of conduit joints using unions.

Nipples.—The right and left are used at each end of every run, excepting when the run is very short; they form a ready means of attachment of fixtures or appliances to the conduit.

Couplings, right-hand, form the regular means of joining the lengths of conduit and nipples.

Couplings, right and left, are used with the right and left hand nipple.

Couplings, reducing, are only used in the special cases when the appliance may be drilled for a smaller size than the local run of the conduit, and, the clearance still being sufficient for the conductor, it is not desirable to enlarge the drilling and tapping of the appliance.

Unions.—Supplementing the use of the pulling box and pull-

ing sleeves, unions *with lips ground off*, are used on the end of all elbows, 90 degrees, unequal legs, outlet elbows, 90 degrees, unequal legs, or special bends to replace them, as shown in Fig. 294. In order that the elbow may be removed from the runs of conduit which they join, and access be had to the conductor when pulling in or out of the conduit, the full benefit of this plan will necessitate drawing wire in straight runs of conduit only, or in those with easy bends.

The unions are made water-tight by a two-ply cloth-insertion sheet-rubber gasket, ⅛-inch thick, and the full width of the surface available in the union. The possibility of water gaining access to the interior of the conduit makes it undesirable to use unions in exposed locations on decks or where they will be exposed to water or drip of any kind.

"Running threads" are inadmissible. This type of joint (sometimes confounded with the "split coupling," and as objectionable) has a long thread which is fitted for an extra half-coupling which screws down against the full coupling after assembly, and intended to act as a lock-nut; the space between the full coupling and half-coupling is packed with lamp wick and red lead. Experience demonstrates that the coupling forms a very insecure joint and breaks open when the pipe is under strain, even that of expansion and contraction.

Bushes reduce from one pipe size to the next smaller where the appliance has been drilled and tapped larger than is necessary for the pipe size that is being used.

Pulling sleeves are rarely used except in the long, straight runs of colliers, auxiliaries, etc.; they are intended to afford a separation between ends of conduits, varying from 9 inches in the ½-inch pipe size to 14, 18, 22, 26, and 30 inches in the larger pipe sizes. The gap permits making a bight in the conductor as it is pulled into the conduit, or of inserting the conductor both ways from the gap when pulled in. The leads of the pulling sleeves are water-tighted on the outer surface of the conduit in the same manner as for standard conduit stuffing tubes. It is desirable to securely support the two conduits on either side of the pulling sleeve that there may be no working on the gasket. It is also necessary to lower the conduit below the edges of the beams for a sufficient distance to draw the full length of the pulling sleeve one way or the other on either side of the gap. The pulling sleeve

is intended to be placed in the straight runs of conduit where the length is sufficient to make the pulling in of the conductors difficult; the friction of the wire at bends is obviated by unions.

Laying Out.—While the tentative wiring plans indicate to a great extent the general trend of the conduit leads, variations are made necessary in the finished work by the many necessities for other appliances than the electrical and some considerations which can be mentioned only in a general way.

Wiring appliances in covered locations should be so located that they will not be subjected to drip or leakage from valves or joints or oil.

Deck or bulkhead fixtures may in many cases be attached directly to the auxiliary machinery with better effect than installing drop lights from the deck or bulkheads.

In locating conduits and appliances to decks the upper side of which are covered by wood deck planking, care must be taken to avoid covering over the deck bolts which secure the planking in place; when it is necessary to renew this wood deck planking access to the ends of the bolts from the under side is necessary in order that the holes may be drilled in the wood, and an unobstructed access to them is required. When practicable to span a distance covered by wood deck planking, it is desirable to secure the conduit to the adjacent steel deck plating in order that, when the planking is renewed, it may not be necessary to remove the bolts from the wood.

All conductors above 60,000 cm. have a separate conduit for each leg and the pairs of conduits constituting each circuit should be kept as closely together as possible throughout the entire length of the run; below 60,000 cm. both legs are run in the same conduit, twin wire being used.

Use templates instead of the appliances themselves. The work will ordinarily be facilitated by leaving the drilling and tapping for ordinary appliances until after the appliances are connected to the conduits and thus avoid the necessity for close fit on the length of conduit run.

When locating an appliance which requires a double run of conduit, and near a deck or bulkhead, consideration must be given to the spacings required for the conduits in the appliances and also for the spaces for the stuffing tubes in going through the

deck or bulkhead, in order that special short bends may not be required in a short run of conduit.

Where offsets in a run of conduit may be saved, and head room will permit, the smaller appliances, such as junction boxes, feeder boxes, etc., may be held clear from the bulkheads or decks, being supported only by the run of conduit, this being attached to the beams or stiffeners.

Keep as clear as possible of all spaces required for passages and for the operation of other appliances.

Avoid overhead runs in hot locations in order to prevent deterioration of the insulation of conductors, and runs near heated surfaces, such as boiler casings or the flanges of steam pipes which are run through bulkheads. The runs in bunkers should be so located as to be as free as possible from damage by the dropping of coal. When running near pipes which are to be lagged, ample room for the lagging should be allowed.

Especial care is to be taken in magazines and shell rooms to interfere the least possible with the stowage space required for the ammunition and a run should be selected which will avoid possibility of damage to the conduit in handling heavy ammunition.

Bending, Cutting, and Threading.

Bending of conduit is done by the convenient apparatus shown in Fig. 295, which consists essentially of a 30-ton oil jack fitted with a notched curved toe, and two shoes which can be conveniently and securely set in the base. When in use the apparatus is strapped to a stanchion.

The jack is secured to the upper part of the casting by a cap clamping it into a recess in the main casting. A threaded collar clamps up against the sides of the recess and cap and rigidly secures it in place. The neck of the casting is reinforced by two steel rods T-headed at upper and lower ends and shrunk into place between lugs.

The jack is operated as usual by the lever shown on the left the lever extending to the right being for rapid movements up and down when no power is required.

A bevelled shoe at the bottom of the jack takes the upper forming block which has a groove cast in its curved lower side which is adapted to the outside diameter of the conduit to be bent and

for the minimum standard radius. These blocks are applicable to one size of conduit only and are readily removable for any other size. The lower forming blocks are double on each side.

The lower part is adjustable for distance from the center. The thrust in two directions is taken up by a single longitudinal extension with several in the transverse direction. The upper part is variable for each size of conduit and can rotate on a pivot fitting in a circular recess in the lower part when adjacent bends are required in different planes.

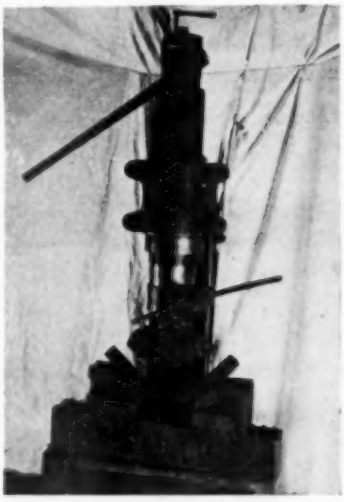


FIG. 295.—Conduit bending machine.

The attention required is that the plunger is kept well lubricated to prevent cutting.

Bending is done to templates of ¼-inch iron rod shaped to the location for the conduit.

Cutting of conduit is done by one of the regular forms of pipe cutter. After cutting, the ends are faced true and square all round before threading, and the inner edges bevelled with the reamer shown in Fig. 296; this guards against abrading the conductors when pulled through the conduit. Reamers are the best for this work, as files do not give a satisfactory result.

Threading of Conduit.—Threads should be of standard diam-

eters, the adjustment of the dies being checked as required; threads should not be cut small by reversing dies.

An excess of oil is to be avoided in cutting and threading and all remaining is to be thoroughly cleaned off, especially inside of the conduit, in order that the painting may be effectual and no oil be present to affect the insulation of the conductor.

FIG. 296.—Conduit reamer.

Painting.

Sabin's air drying enamel is an approved paint for enameled conduit.

All conduit, excepting in quarters, should receive after installation not less than two good coats in order to thoroughly protect the surface from corrosion. This is especially important in fire-rooms, up-takes, bunkers, engine rooms, shaft alleys, upper decks, masts, conning-tower tube, and galleys. In quarters and other locations where not especially exposed it will be sufficient if the conduit receives the regular white oil paint.

The directions for the use of the enamel are:

Do not use any thinner.

In cold locations it may be warmed to make it more fluid.

It will usually require 36 hours to dry sufficiently to handle. In hot dry weather it may dry in 12 hours. If dried by heat (200 degrees to 250 degrees F.) it will dry in about two hours.

A second coat should not be applied in less than three days; and 10 days is better.

The success of the application of the enamel will always depend on the cleanliness of the surfaces and their freedom from grease and oil.

Templates.

The templates for fitting the bends required in the conduits are ¼-inch diameter, round, iron rod, those for fitting special straps 1 inch by 14 B. & S. G. band iron.

Elbows and Bends.

Insulating outlet elbows are to be used only where no other method will answer.

Use elbows as often as possible instead of making bends in long lengths in order that there shall be less reduction in area and that unions may be used at their ends.

All bends are made in the hydraulic form of benders; bending by heat usually flattens the pipe and can be tolerated only for small or twin wire.

There must be no detrimental flattening on any bend. A bend in which the area is materially reduced must not be used.

When heated bends are made for special locations they must be thoroughly enameled inside and out.

Water-tighting.

Conduit is to be continuous and without open joints. Where required to be water-tight at bulkheads and decks the standard stuffing tubes or jamnuts are used; the latter to be used only when the standard stuffing tubes cannot be installed.

When leading from a water-tight compartment to a non-water-tight compartment, or the reverse, or from a water-tight compartment to a compartment in which there is an outlet, and through all decks, the conduit is to be water-tighted inside each water-tight compartment by the use of water-tight boxes, however short the run or despite the fact that the conduit may be only led

through the compartment in going from one to another; this rule should be inflexible as otherwise the intent of water-tighting (which is to protect a water-tight compartment from the inflow of water from any other compartment) is not efficiently carried out.

In going through decks and bulkheads the circuit is made water-tight around the conduit by standard stuffing tubes.

If the conduit starts and ends in the same compartment, being used for mechanical protection only, water-tighting is not ordinarily required at either end; the possibility of chafing the conductor on the edge of the conduit at the ends is prevented by the use of an outlet insulator.

Clearance.

The clearance determines the pipe size of conduit for use with the size of the conductor. A clearance of from 5/32 to 3/16 of an inch is to be allowed for drawing circular conductors in and out; for oval sectioned conductors this may be reduced to from 3/32 to ⅛ of an inch.

Caution.—The apprehension in pulling (or drawing) conductors is that the rubber insulation on the wire will be broken and fractured, it is particularly a menace in conductors which have been manufactured six months or more. As the copper is very ductile, the rubber insulation liable to fracture, and the braid to stretch, rupturing the insulation is comparatively easy under the large stress which is necessary to draw a large wire, say, of 200,000 cm. and above; hence a safe clearance allowance is mandatory, and this is especially to be looked out for in bends.

Inspecton.

Before putting up any length of conduit fitting look through each length of conduit and each fitting to see that the bore is smooth, of full diameter and of circular section.

It must be seen that the inner edges at the ends have been properly bevelled or rounded, and that a full, strong thread has been cut; the fusing of a bend on board an armored cruiser, causing fire in a magazine, has been caused by neglect of this injunction, the insulation of the wire having been stripped by the cutting edge of an elbow in drawing.

Insulators.

An incidental advantage of the use of this method which is of especial value in crowded locations, such as dynamo-rooms, is in the short bends which can be made in the conductor as compared with conduit work.

The following table is useful as a guide in laying out work, and indicates the minimum safe, inner surface, radius of bends which can be used without detrimental stress on the rubber insulation or protecting braid:

Wire for Lighting, Motor, Etc., Circuits.

Single.		Radius.
4,000	cm.	2 inches.
9,000	"	3 "
11,000	"	3 "
15,000	"	3 "
18,000	"	3 "
20,000	"	3 "
30,000	"	3 "
40,000	"	4 "
50,000	"	4 "
60,000	"	4 "
80,000	"	5 "
100,000	"	5 "
125,000	"	5 "
150,000	"	6 "
200,000	"	6 "
250,000	"	6 "
300,000	"	7 "
375,000	"	7 "
400,000	"	7 "
500,000	"	8 "
650,000	"	9 "
800,000	"	10 "
1,000,000	"	12 "

Twin.		Radius.
4,000	cm.	2 inches.
9,000	"	3 "
11,000	"	3 "
15,000	"	3 "
18,000	"	4 "
20,000	"	4 "
30,000	"	4 "
40,000	"	5 "
50,000	"	6 "
60,000	"	7 "

Inter-Communication Cable.

		Radius.
2	Conductor	3 inches.
3	"	3 "
4	"	4 "
5	"	4 "
6	"	4 "
7	"	4 "
8	"	4 "
9	"	5 "
10	"	5 "
11	"	5 "
12	"	5 "
13	"	5 "
14	"	5 "
15	"	6 "
16	"	6 "
17	"	6 "
18	"	7 "
19	"	7 "
20	"	7 "

The types of insulators have already been described. There is a new variety for use with sheet metal hangers consisting of a flanged bush, one part screwing into the other and thus adjustable after the hanger has been put in place.

Molding.

The backing strip, laid in advance, is secured by brass machine screws (No. 14-20), placed alternately on the sides, and so spaced (about 12 inches apart) that no screws will come under junction boxes, switches, or receptacles; the screw heads being countersunk.

Molding is secured in place through the center wall with brass wood screws (No. 8, 1½ inches). Screws are placed, as directed, at intervals not greater than 12 inches; the screw heads being countersunk to make a fair surface for the capping.

Molding is finished in the same manner as the surrounding woodwork, and all molding and backing except hard wood is thoroughly coated with white lead paint after being fitted and before being secured in place. All molding is capped, *the capping being secured to the side walls* by roundhead brass screws placed not more than 12 inches apart.

In running the backing strip a path that will clear usual sized

boltheads and other projections is chosen. To avoid such obstacles, small detours from a direct lead are allowed.

The part of the molding under the wire gutters is never reduced in thickness below ⅜ inch.

Junction boxes, switches, and receptacles (combined or separated) are separated from metal surfaces by at least ¾ of an inch of wood, and secured with brass wood screws entering the wood for ½ inch. It is required that at least ¼ inch of clear solid wood shall separate all wiring accessories from the metal of the vessel.

The junction boxes, switches, and receptacles being wider than the backing strip, the latter are always built out to bring it flush with their sides, except where a number of moldings are grouped together, as in passageways where feeders are run; then these boxs can be let into adjacent moldings (never more than 3/16 inch) and so disposed that no two in adjacent moldings will be abreast. They are never located over screws which secure the backing in place.

Controlling switches, feeder junction boxes, and distribution boxes are placed with especial reference to convenience of access.

Where several leads of molding run side by side, a backing strip of the required thickness in one width may be used under all.

When the run changes from molding to conduit or the reverse, the end of the conduit is fitted with a standard conduit terminal tube. The backing strip of the molding extends under the terminal tube, and the molding part cut off square about 3 inches away from the end of the assembled gland. The capping extends beyond the end of molding and butts up against the gland. Two side pieces are fitted from the end of the molding proper to the terminal tube, thus forming a sort of box to give room for access to the gland and gasket of the terminal tube.

Neither twin-conductor lighting wire, nor any other double conductor or cable which would be liable to cause dangerous short circuits by being damaged, are installed in molding.

Electrical Interior-Communications.

The installation of conduit and molding for interior-communication is in accordance with that described for lighting.

Wiring.

All wire, whether for use on dynamo current or battery is that prescribed by the specifications for bell wire and interior-communication cable; the specified bell wire and interior-communication cable is used on all circuits, whether for call bells, telegraphs, or indicators, excepting where a standard special cable has been specified for a particular use.

Interior-communication cable is used for all circuits below the main deck; bell wire may be used in quarters and for offices the governing principle to be to secure thorough water-tightness between the water-tight and non-water-tight sections of the vessel, which will necessitate in some cases the extension of the cable into the non-water-tight sections through the water-tight bulkhead. Not more than 40 wires are used in any one lead. Interior-communication cable is also used for circuits to the conning tower, chart house, military top, signal towers, emergency cabins, and bridge.

When using interior-communication cable, the number of spare wires in each cable is not to be less than one for cables up to nine conductors; not less than two for cables up to 21 conductors, and not less than three for cables up to 40 conductors.

Ten-wire, 20-wire, and 40-wire connection boxes are used as may be most suitable for the particular case, special reference being had to reducing the number of boxes to a convenient minimum.

All wires or cables are run where directed and where accessible, those for circuits used in action being kept below the water-line as much as possible.

Action Cut-out Switches.—Circuits used in action which are protected, and which are connected to exposed circuits, are provided with action cut-out switches for cutting out the exposed portions of the circuits.

The use of action cut-out switches is limited to such switches of interior-communication as are used in battle *and does not include the following (except as noted in case 3)*:

Voice tube calls.
Telephone calls.
Quarters and office calls.
Boat hour gongs.
Alarm gong circuits.
Fire alarms.
Warning signal circuits.

The following are always provided with this type of switch:

Shaft indicator circuits.	Steering telegraphs.
Engine revolution telegraphs.	Helm angle indicators.
Battery control.	Power door indicator circuits.

Their use on these circuits is determined as follows:

Case 1. More Than One Transmitter on a System.

If one or more transmitters are located behind armor and one or more transmitters are not behind armor, circuits to those not behind armor are fitted with cut-out switches.

If none of the transmitters are behind armor no cut-out switches are installed on the circuits to the transmitters.

If all of the transmitters are behind armor no cut-out switches are installed on the circuits to the transmitters.

If one, any or all, transmitters are located behind armor and some indicators are not behind armor, cut-out switches are installed on the circuits to such indicators.

If none of the indicators are behind armor no cut-out switches are installed on the circuits to the indicators.

If all the indicators are behind armor no cut-out switches are installed on the circuits to the indicators.

Case 2. Only One Transmitter on a System.

If some indicators are behind armor and other indicators are not behind armor, cut-out switches are installed on the circuits to such indicators as are not behind armor.

If none of the indicators are behind armor no cut-out switches are installed.

If all of the indicators are behind armor, no cut-out switches are installed.

Case 3. When voice tube calls, telephone calls, general alarm wiring and warning signal wiring extend from outlets in conning tower up to pilot house or bridge, cut-out switches are fitted on all such circuits before they leave the conning tower.

General Directions as to Wiring.

The outer braid and tape on the ends of all bell wire and cable, where they are connected through gaskets in boxes, cut-outs or instruments, is not removed, as was the older practice.

All wire and cable run through decks or bulkheads, when molding is used, are led through standard stuffing tubes. When run-

ning through beams or bulkheads, and water-tightness is not required, the hole for the lead is bushed with hard rubber when molding or insulators are used.

No circuits are led overhead in locations subject to heat, or through or into coal bunkers, unless specifically necessary.

All conductors are run in conduit; insulator and molding work being specially authorized and approved.

Soldering Joints and Wire Ends.

The number of soldered joints in single conductor circuits must be entirely avoided if practicable. When soldered joints are made it is done by first cleaning the wires, then twisting closely together and heating only sufficiently to cause the solder to flow freely into the joint. The heating is preferably done with a soldering iron. If a soldering lamp is used special precaution is taken to prevent overheating of the rubber. The solder for making joints is of the rosin core type; no flux other than rosin is used. All joints are taped while warm with a layer of rubber tape, and covered with an outside layer of cotton tape for protection against mechanical injury.

In making joints between bell wires and interior-communication cables, the interior-communication cable is run through the watertight deck or bulkhead into the location where the bell wires terminate and the junction there made in standard connection boxes.

Soldering the ends of conductors in order to fix the single wires of the strands when they are to be inserted under binding caps is bad practice and is not admissible; the fringed wires make better contact and hold more securely than the soldered end. Soldered ends frequently slip out from beneath the cap. A "soldered end," however, is not to be construed to apply to soldering the ends of wires into connectors (Fig. 90, *A*).

Fishing.—All short lengths which can readily be handled by one man are fished with the usual steel snakes.

In long lengths the first line through is led from the device, to be connected with the compressed air nozzle, shown in Fig. 297; the air pressure being supplied in ships so fitted, from the air pressure lines used for the drills, chippers and riveters. In ships not so fitted a hand operated air pump is used. After the fish line is blown through a hemp line is attached to supply the strength required to draw the conductor.

In operating, the soft leather bucket is pushed into the conduit, the nozzle is inserted into the end of the conduit, and the cock then opened. The device, on test, drove the bucket through 350 feet of conduit and past four bends in three seconds; the soft leather bucket is more efficient than a ball or other arrangement.

FIG. 297.—Device for blowing a reeving line through a line of conduit.

FIG. 298.—Cable grip.

The line used is small fishing line which, after being driven through, is used to haul larger line, rope, etc., through.

Cable Grips.—For drawing cables and conductors in conduits the connection between the conductor and the rope is made by the cable grip as shown in Fig. 298. The grip is made in the following sizes:

1¾	inches	to	⅞	inch.
1½	"	"	¾	"
1	"	"	⅝	"
¾	"	"	⅜	"

The tension on the grip causes it to close in and bind the outside of the conductor so tightly that any necessary tension for pulling the conductor through the conduit will not cause it to loosen and slip.

Lubrication in Pulling Conductors.

Soapstone powder is to be blown by a bellows or by the compressed air fish device before entering the conductor. It is also always to be rubbed into the outside braid of the conductor to facilitate drawing in; and especially for the purpose of preventing the conductor from sticking in heated locations, causing extra stress in drawing and withdrawal.

The utmost care is to be taken to prevent the powder from getting on any parts of adjacent machinery which it can damage, especially their journals and lubricators.

Inspection After Completion of Work.

After the conductors have been placed and connected the integrity of the conduit work must be inspected at all its joints in couplings and unions.

The unions must be slacked back, and the use of the gasket and its having even contact definitely determined.

The tightness of all covers of all boxes is examined and the condition of all gaskets in pulling sleeves, deck, and bukhead stuffing tubes.

The condition of the painting in all locations especially requiring enamel is looked into when going over the points previously mentioned.

Jointing Up and Securing.—All joints must be screwed up tight, as for steam or water under pressure.

A right and left coupling must have an even number of threads in the conduit in each end.

In entering appliances it is necessary that the end of the conduit shall come flush with the inside in order that the conductors may not be abraded by the sharp edges of the thread before being protected by the bevelled inner edge of the conduit or nipple.

Circuits are led through armor by drilling a clearance hole and inserting a long nipple, the conduit being connected by a coupling or a union on each end; water-tightness is secured by jamnuts screwing along the nipple tight against the armor, one nut on each side.

During installation the ends of conduits on exposed locations must be closed by wooden plugs or oakum to prevent access of rain and damp air to the interior of the conduit; to the same end box and instrument covers should be installed with the least practicable delay.

Gaskets.

When gaskets are used for water-tighting around the outside of the conduit, the conduit may first be installed without the gasket, and then each gasket as installed may be cut along the line parallel with the axis of the hole; the gasket can then be forced open and slipped around the conduit. Care must be taken that the gasket is closely joined together when set up and thoroughly seals the cut. The location of the cut on inserting the gasket must be such that it can be readily inspected when the gland is being set up.

The packing of covers of boxes should be rubbed with chalk or soapstone to ensure that they will not stick to the edge of the box and prevent the ready removal of the cover.

Particular Hints and Some Faults Occurring from Errors of Management.

The Turret Base.

This term refers to a casting, about 12 inches in diameter, through which are led the circuits for the turret. Its object is to centralize these circuits to minimize the twist when the turret is revolved; the number of circuits may be as great as 17 and these must be massed as closely as practicable around the center spindle or air-pipe.

The casting usually consists of two ½-inch composition plates between which is compressed a circular gasket of soft rubber, ½ inch thick, the rubber binding against the circuit wires to hold them tightly in the base and prevent any twist within the water-tight box beneath the handling room (and located as a rule over the center line bulkhead between two magazines).

Four methods of construction of this base casting are in use: *One*, in which the casting is bored larger than the diameter of the wire, the soft rubber being bored for a neat fit around the wire and in this case only the compression of the top plate can be relied on to water-tight the wire and grip it against the probable twist

in the box below (which would endanger chafing off the insulation as has occurred); *a second*, is to bore the casting and rubber as in the last case, but in addition to bush the bores of the castings with hard rubber, this is an improvement on the first plan, but still insufficient to prevent twist; *a third*, provides more compression of the soft rubber against the twisting effect by soldering rings to the cap and bottom plates at each bore and cutting channels in the soft rubber, a method that proves to secure better rigidity; in the *fourth and latest* method, the entire construction is changed and the wires held securely in separate stuffing tubes screwed and soldered in a single plate casting, a ¼-inch gasket is assembled with the plate for water-tighting.

Distributing Twist Above the Turret Base Casting.—As the turret circuits are of unequal wire size, the effect of the twist when the turret is revolving is different for each wire size causing chafing not only of the wires on the central pipe, but on themselves. This is best obviated by using sleeves cut from brass tubing, giving a clearance of ¼ inch on the wire and about 10 to 12 inches in length. These are slipped over the air-pipe and spaced equally in the height from the turret base up. From six to eight sleeves will suffice for a 12-inch turret and four to five for an 8-inch turret. The wires are brought in and seized to the sleeves with steel wire seizings, the sleeves being preferably drilled for the purpose. The method will evidently prevent any chafing and adds much to the neatness of the assemblage.

Circuits Inside of Magazines.

Present rules require that when a circuit which is to be fed at dynamo potential is led through or into a magazine or shell room the conduit shall be protected by a covering ¼ inch thick (10-pound plate). No circuits should therefore be led into or through these compartments, and thus involve the extra weight, if it can possibly be avoided; the one actual necessity is for the circuits leading to the water-tight box under the turret base casting.

For lower potential circuits, such as those for thermostats, no covering is required; but for the general case of the thermostat, its location at the side rather than the upper center of the magazine or shell room is sufficient for its intended use.

Running Conduit Through Beams.

This practice is so general, although against all rule, that it is again emphasized as to be prohibited.

Voice Tube from the Starboard Bow to the Bridge.

This very convenient voice pipe is commonly omitted. Its installation is quite important as conducing to quiet when working anchors and chains.

Taffrail Lights.

The installation of outlets for the stern light, peak light, propeller boom lights and for deck lights about the taffrail is much simplified by a device consisting of 1¼-inch conduit with two T branches, on which can be installed five switch-and-receptacles. The conduit is led up from below and goose-necked to turn down with the flag staff out of the way of the guns. The device is contained in a standard drawing.

Securing Lights Under Beams.

This practice of securing fixtures under the lower flange of channel beams invariably results in insufficient head room under the globe and should be prohibited, except in certain cases inside of quarters, even then there exists no real necessity and an avoidance of the practice altogether is advisable. The rule for securing fixtures is to secure them in almost every case to the deck above to the entire exclusion of locations against a beam, and if the resulting dispersion appears then to be insufficient the proper practice is to install more fixtures.

Circuits in Hot Locations.

The chief of such hot locations are the upper parts of fire-rooms. In general no circuit should be led into or through any fire-room if it can be at all avoided; the main circuits and especially interior-communication circuits should be located in the passages; in the repair of former installations where circuits had been led through fire-rooms from apparent necessity a new lead in the passage has been found without difficulty, and no exception is known.

Cases of melting off the insulation from wiring are common when subjected to fire-room temperatures.

Helm Angle Indicator.

An indicative cause of faults can be instanced in the frequent faults in this instrument; in all cases the fault has been due to condensation within the contact box or to dropping short-circuiting matter into the box when cleaning it out.

Appliances on the bridge frequently fail from this corrosion from condensation or from not keeping the cover packed; it is also a usual cause of failure of telephones—salt water and air is the chief occasion.

Wiring Appliances.

No appliance should ever be covered until cleared of all foreign matter, such as filings or copper dust from the wire ends after cleaning and brightening before securing under the contacts.

Tests After Installation.

The acceptance tests of the material apply to the original supply only; subsequent inspection of the generating sets, wiring appliances, fixtures, apparatus, and instruments is to assure their efficiency and construction after shipment, and after placing in the assigned location in the ship; but the object of the test is to assure that the installed material is in condition for commissioning the vessel and hence in contract work the original acceptance tests are provisional only, and the material accepted preliminarily and to be subjected to the final tests for final acceptance; to this end the tests should not be made until within a short time of the vessel's delivery, and not greater than two months previously.

So many items intervene that it is not practicable to formulate any exact chronology of the tests required, but they can be outlined for the general case by referring them to the 48-hour service test which is in reality especially intended as a test of the generating sets and during which there is not sufficient time to undertake a careful test in other regards. In the following outline the time required is about ten days.

Test of Insulation Resistance, Cold.

When measuring the ohmic insulation resistance of lighting circuits 125 volts is now used for the potential, but 500 volts is preferable if available. Hereafter the lighting circuits are to be

tested by alternating current; all lighting circuits having metal sockets in line are tested at 500 volts A. C., and all other lighting circuits at 750 volts A. C., the tests to be made in dry weather after an inspection of the appliances and accessories to see that they are free from moisture and dust. The current is supplied from an oil insulated static transformer which is ordinarily supplied with current from the alternating current dynamo of the motor generator for wireless telegraph installed in the vessel. The output of the transformer is rated at 600 watts and with a range of secondary voltage of 250, 500, 750, 1000, 1250, and 1500 by taps from the secondary winding. The primary is adapted for 110 volts, 60 cycles. Of the taps the 250, 500, and 750 only are run out and made selective by a switch. An alternating voltmeter of scale to over 750 volts is supplied to be put across the secondary terminals of the transformer.

Caution.—Great care must be exercised in handling these high voltage currents as the peak of the wave is 40 per cent higher than the values stated, which are mean, *making each one including the lowest dangerous to life.* When the circuits are being tested special precautions should also be taken to prevent all other persons from handling them in any way.

The insulation resistance of motor circuits is usually tested at a potential of 500 volts, if available, otherwise 125 volts is employed.

While it is common practice to test the insulation of interior-communication circuits at 125 volts, 500 volts is better in its results and gives more accurate indications of the actual; this has been the invariable practice at the New York Navy Yard. In fact all insulation resistance, other than by alternating current, has been tested at that navy yard at 500 volts using the ohmmeter as a material time-saving device. The Evershed type is that in use and is an adaptation of the two-coil ohmmeter with a portable hand dynamo yielding a continuous current. The electrical principle is indicated in Fig. 299. The current from the dynamo D divides at the ohmmeter into two parts, of which one flows through the pressure coil P, and constant resistance R, and tends to turn the magnetized needle and index hand towards the infinity point on the scale, while the other fraction of the current traverses the windings of the current coil M and the leakage path X through the insulation which is under test.

When there is no leakage the current coil has no force and the

needle is free to lie in the magnetic axis of the pressure coil; the index then stands at the last division of the scale, which is accordingly marked "infinity." If the insulation resistance is so low as to be negligible, the current flowing through the current coil will depend only on the volts and the resistance of the current coil itself. The current coil will now deflect the needle away from "infinity" to a position in which the turning moments of the two coils are balances.

This point on the scale is marked "zero." Obviously, for any

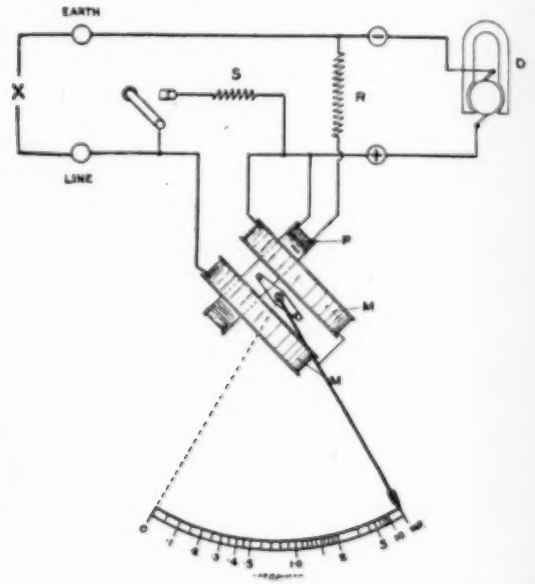


FIG. 299.—Diagram of circuits of the Evershed ohmmeter.

given resistance in the leakage path the index will come to rest at a definite point between zero and infinity. Moreover, if the resistance is constant and independent of the voltage, the position of the index will not be changed by increasing or decreasing the volts, for if the volts are doubled, for example, the currents in both coils will be doubled and their ratio remains unchanged. Hence the angular position of the needle and index indicate resistance quite apart from voltage.

This instrument directly indicates the value of the resistance

under test by means of a pointer which ranges over a scale of ohms and megohms, just as an amperemeter indicates amperes or a voltmeter, volts.

In the latest pattern of Evershed testing set, the hand dynamo has a tunnel wound armature, a finely laminated core built from stampings of best iron, a special form of commutator with elastic roller brushes and roller bearings for the armature axle. It is driven by double gearing. The winch handle is hinged so that it may be turned down into a recess in the box when not in use. A convenient flexible connector is provided for coupling the dynamo to the ohmmeter. The ohmmeter has a very finely pivoted astatic needle system, magnetized by the dynamo current, and, therefore, free from all the troubles incidental to permanently magnetized astatic needles. The needle system is automatically lifted off the jewel bearing and securely clamped by the action of shutting the lid of the box. The current coil is wound with a large number of turns of fine wire to secure the maximum sensibility. A one-ninth shunt is provided to reduce the sensibility ten times when low insulation resistances are being tested. There are four terminals on the ohmmeter; two of these serve for the connections to the dynamo, and the other two are marked "line" and "earth," respectively, and to these the circuit which is to be tested must be connected.

There is no adjustment of any kind to be made beyond turning two leveling screws on the ohmmeter until the bubble of a circular spirit level stands central. The scale reads in megohms.

It is essential in operating an ohmmeter that it be level and removed from the vicinity of iron; neglect of these precautions produce very erroneous readings.

A good preparation for the final insulation test is to ring through each line of wiring with a magneto as the wiring is installed; this instrument having a resistance of 50,000 ohms that much insulation of each leg of the circuit to ground is thereby assured. Failures of insulation resistance are in many cases to be located in a badly placed fuse in a feeder or branch box, emphasizing the necessity of the inspection of all wiring appliances and connections before the insulation test is made; if the fault is not to be located in these connections an elimination from box to box and circuit to circuit is necessary.

When making the cold insulation resistance test all lamps are left in their sockets with switches turned off, and all portables are unplugged; all motor circuits are to be cut out at the switchboard, but are tested separately as far as the main switch connecting to the panel or rheostat.

The 48-Hour Service Test.

This is a test of endurance of the generating sets and the incidentals thereto, each generating set being required to run on some load between full load and no load, and for two hours on one-third overload, for a continuous period of 48 hours.

Ordinarily but two sets are run at the same time owing to the congested space in ships' dynamo-rooms, the number of people required, and the lack of necessary space for instruments and recording data; and incidentally the fact that night work and overtime is required, it being necessary to reduce the last to a minimum.

For the load, all that is available in the ship should be first connected in; for a battleship this will be about 1200 amperes, the searchlights not being considered as they cannot be safely run for more than two hours at a time, and, excepting in the case of the one-third overload, should not be used for the purpose of the test at all; there will, therefore, be required to be prepared beforehand—in view of the paralleling test—at least 1200 amperes in water rheostats for generating sets of 100-k. w. capacity, to give the necessary load of 2400 amperes for the total test.

Two sets may be started about four hours apart, though an interval of six hours is better; if three machines are to run a less interval than eight hours apart will be found to be very inconvenient for recording.

Before Starting the Test.

1. Prepare the log sheets. These should contain all the data of the test with a large column for remarks to include all incidents; especially are to be recorded the fact of testing the valve settings, brush positions, compounding, etc., which are often adjusted before the service test is made and not examined into in time to avoid loss of time when required to shut down; the adjustment of the valves and brush settings and compounding should be ascer-

tained as soon as the set is steady on the load that there may not be one position of the brush for the paralleling and another for the heat run.

The log sheet should be comprehensive of all details of the machine itself and every minute of the test.

2. Have all gages and instruments calibrated. As in acceptance the accuracy of the gages and instruments is most conveniently expressed as a factor.

3. Provide thermometers for the heating tests; the thermometers should read in divisions of one degree between zero degrees and one hundred degrees centigrade, and should be about six inches long, the mercury bulb to have a diameter of about 3/16 inch, and not greater than the diameter of the stem.

4. Provide water rheostats for all load for paralleling three machines, about 1200 amperes for 100-k. w. generators.

5. At some time within about three days of running the test take a characteristic of each generator, in five steps, from full load to no load and back to check the brush positions in conformity with the specification that the characteristic must not vary more than 2½ from the rated voltage of the generator at any point of the curve. It has been found that the compounding of generators is changed during shipment, and after the preliminary acceptance test, and since the series shunt has been permanently adjusted it becomes necessary to readjust the compounding for the new conditions by shifting the position of the brushes, that is the rocker; this should then be marked by a file or chisel, and the position maintained for both the heat run and paralleling.

6. Provide and examine the oil; this oil to be that as generally used in ship work, and as prescribed in the tests of generating sets.

7. Measure the cold temperatures of all the locations as prescribed in acceptance tests, except that of the field, by thermometer. Measuring the heat rise of the armature and series windings by the method of electrical resistance is too delicate a test for tests on shipboard; and the method should not be attempted.

The Service Run.

The data are taken every half-hour and include volts, amperes, R. P. M., steam, vacuum, temperature of air, temperature of field,

and remarks; at random on the sheet are notes of the other requisites, but incidentals of test during the run are entered opposite their proper hour in order that the time and fact may be fixed, being thus complete and accurate for future reference, the *desideratum* being that the test shall be complete and separate in itself.

1. Start the set and adjust all running conditions for operation under full load and when steadily in operation under full load take a good card for examination of the valve settings; if satisfactory, note from the card the steam pressure at the throttle and adjust the reducer for the drop in pressure from the gage tap to the throttle.

Next take a characteristic in five steps from full load down to no load and back to check the compounding and brush position.

Run the set on full load for two hours to warm up the windings before taking the efficiency cards.

2. At the expiration of two hours take a set of cards at ¼ load, ½ load, ¾ load and full load; examine each for the accuracy of the valve settings and file the cards for calculation of efficiency for each stage of load. No-load cards are of negligible utility. If the valve settings are unsatisfactory the set is shut down and a complete new run made.

3. As soon as the verifications of 2 are made adjust the load to one-third overload and run for two hours, taking a good card during the interval for efficiency calculations.

(The valve settings having been examined and the overload run made, there will not be further chance of having to shut down and loss of time will be avoided.)

4. Adjust the load to ¾ load and run until the expiration of the 18th hour.

5. At the end of the 18th hour adjust the load to ½ load and run on that load for 12 hours.

During this period opportunity is usually afforded to test the action of the set under varying steam pressure for vacuum and atmospheric exhaust; the tests required are:

a. Operating on full load, to run at a steam pressure 20 per cent below the normal and on vacuum exhaust.

b. Operating on 90 per cent of full load, to run at a steam pressure 20 per cent below normal and on atmospheric exhaust.

c. Operating on full load, steam pressure 20 per cent above normal, atmospheric exhaust.

d. Operating on full load, steam pressure 20 per cent above normal, vacuum exhaust.

The run should be made for 30 minutes under each condition, and during the time the regulation of the engine for the condition is tested by breaking from the operating load to no load and back three times, noting the initial, final and steady speed and voltage each time, the average being taken as the result for each condition. (It has been customary to take the engine regulation when operating at one-third overload; the practice is likely to occasion serious accident to the engine and should not be tried.)

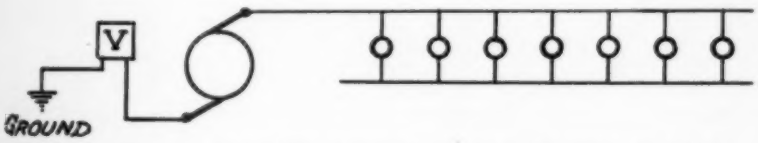


FIG. 300.—Illustrating method of test through circuits under load for insulation resistance.

6. Next adjust the load to ¼ load and run for 12 hours.

During this run opportunity will afford to test the insulation resistance of all the circuits whilst hot. All lights and portables which that circuit is designed to carry are turned off, and the insulation resistance of each leg of each circuit is then measured to ground in the same manner as in taking the cold resistances, and by voltmeter, the ohmic resistance only being measured.

7. The last six hours of the run is required to be made under full load.

Shortly after the set is running steadily test the engine regulation by breaking the load from full load to zero and back in three cycles noting the steady, final and initial voltage and speed; hunting and racing are to be particularly noted.

At some convenient time during the earlier stages of the run take a careful characteristic in five steps, beginning at full load and stepping to no load and back, and then a second curve beginning at no load.

At a later stage test the insulation resistance of all the circuits whilst under load, all lights being turned on and all portables

being connected; the diagrammatic arrangement is shown in Fig. 300.

Towards the end of the run make ready for taking all temperatures and just before shutting down get accurate readings of the voltage across the shunt field (shunt rheostat not included) and the field current.

8. As soon as the set is shut down measure the final temperatures by thermometer of: Armature, bearings, pole tips both entering and trailing, series field, field rheostat, binding wire, commutator, correcting for the temperature of the air and referring to the temperatures when cold for the heat rise during the run.

Next measure the insulation resistance of the generator windings.

Operation in Parallel.

The paralleling test should be made with hot conditions, and if opportunity is not afforded after the service run the machines are to be run until warmed up before making the test.

One machine should first receive an overload and the second then paralleled in, noting the voltages of each machine and its division of load after the operation. Next adjust the voltages of each machine until the division of load is equal, the difference in voltage of the machines for this operation will evidently determine whether the equalizer resistances are properly proportioned; if not, there will always be an unequal division of load between the two machines when at the same voltage and the equalizer resistance should be rectified. This test should be made separately for each machine, paralleling successively with the first.

Having again overloaded the first machine, throw in the second, adjust equal voltage on each and a little lower than the normal and then throw in the third, finally adding load to bring all three up to full load.

Circuit Breakers.

The reliability of all circuit breakers should be tested by subjecting them to overload and checking their sensibility; the required overload not being obtainable, the test is made by slowly reducing the setting by the gage and noting the current as shown by gage when the breaker trips; it is advisable to check the gage at two or more other points. Sufficient current for testing large

capacity breakers is rarely obtainable, and shop tests are therefore accepted.

Searchlights.

These are run for two hours, and the rise in temperature of the windings, barrel, and mirror measured by thermometer.

Motors.

The final test of motors on actual drive is a completion of the general test and as in generators temperatures are taken by thermometer and all apparatus in connection with their operation tested out fully under its service use.

Notes on Final Tests.

The shunt field resistance is measured as the test progresses by taking readings of the current and voltage, this includes the resistance of the rheostat. The cold resistance is taken as that of immediately after starting, but it must be taken almost immediately thereafter, as the field warms up quickly, expedition is therefore necessary; the cold resistance may be measured before starting by the drop of potential method, and this is generally to be preferred.

In taking the temperature of a heated armature the maximum reading is obtained shortly after shutting down, in about one minute; the bulbs of the thermometers are inserted in the armature openings, such as ventilating openings on the back head, in ventilators of the core and on the binding wires.

In reading temperatures record each rise as it occurs and until the readings show a decided decrease, this will assure the maximum.

When sets of different sizes are to be tested in parallel, extra precaution should be taken as to the exactness of the equalizer resistances or the smaller machine may be easily overloaded to the point of danger; the practice is a delicate one at best.

Tests of generators and all apparatus of a ship building at the works of private yards are under the control and direction of the owners and at their risk, inspectors should, therefore, merely indicate the requirements and observe the test; interference in other respects occasions claims for damage and delay.

A service test that should be made during paralleling is the breaking of the whole load whilst two machines are operating on full load, and then throwing in the original load on the two machines; it is taking risk to perform the experiment with three machines under like conditions, although more nearly simulating what might occur in action.

DISCUSSION

The Naval Profession.

(See No. 122.)

Commander C. S. Stanworth, U. S. Navy (retired).—I am glad to see that the suggestions of Captain B. A. Fiske in his article on "The Naval Profession," relating to a change in the uniform of the enlisted force of the navy, have met recognition by the appointment of a board to revise the uniform.

With the multitudinous machinery and numerous gearings found on board ships of war, the loosely hanging neckerchief and flowing collar present a constant menace to their wearers. This has been met by the partial adoption of dungarees, though the reason assigned is not the proper one. I should like to see dungarees adopted as the working uniform for all drills other than parade drills. The color will blend with the war paint on shipboard, in time of war, or with the landscape ashore.

By the adoption of ordinary trousers a man can attend a call of nature without unbuttoning fourteen or more buttons. Besides, by the adoption of a simple uniform, such as suggested by Captain Fiske, the labor of manufacture will be lessened, and the uniforms can be furnished the men at less expense.

And with the sweeping away of all the numerous petty details accompanying the present uniform, it will be an easy matter to keep the crew in uniform, and we will be spared the absurdity of seeing at "Admiral's Inspection," his staff gravely measuring with a finely graduated ruler the width of tapes and spaces.

How the flat cap as a uniform for sailors has survived so long is a mystery. It is expensive and frequently lost.

Of course objections will be raised to the adoption of such a complete change of uniform, on account of the large amount of stock on hand, and the consequent financial loss to the government. The navy has a large amount of stock on hand in the shape of antiquated ships and material, but it does not prevent the country from building ships of the latest design and purchasing modern equipment for them. We find less difficulty in obtaining new ships, than we do in enlisting men to man them.

The present uniform is conspicuous, even in our larger seaports, and whereas one hundred sober, well-behaved liberty-men will attract no particular notice or favorable comment, the sight of one man in uniform, drunk or disorderly, leaves an impression upon all beholders inevitably associated with the uniform. And it is such impressions that have created the social prejudice against the admission of men in uniform to skating rinks or respectable dance halls.

Moreover the men desire the change, and anyone who has noticed the

general bracing up of men promoted to chief petty officers, when they don their new uniform, will realize that clothes come very near making the man.

Lieutenant-Commander RIDLEY MCLEAN, U. S. Navy.—Possibly I differ inherently from the essayist in that I am rather optimistic in regard to present naval conditions, though I am not oblivious of our multitudinous defects nor unmindful of improvements yet to be made. I appreciate the value to the service of his clear presentation of the many features of our profession, and the benefit which cannot but accrue from suggesting them as subjects of thought. It is, therefore, unfortunate that by his pessimistic attitude, unfair analogies, and personal criticisms, the essayist will probably incite an antagonism which will largely rob his paper of the serious study it otherwise merits.

After carefully reading "The Naval Profession," the old saying, "Give the devil his dues," seems to me to have been violated. Are we wholly bad, or has the navy been painted in worse colors than it deserves? If so, was this done deliberately through an effort to increase our efficiency, or was it due to a pessimistic attitude on the part of the author?

Had this essay appeared, say ten years ago, these criticisms would have been more appropriate. We were not then preparing for war; we rarely cruised in squadrons; we had, so far as I know, no policy. But why hark back to those times? Since then we have awakened; the hand of one who might be compared with the essayist's Rockefeller, Scott, or Stewart came to the helm, and we have seen the policies of Admiral Taylor develop during his life, and continue since his death under the administration of his able successor, until just at the present moment (August, 1907) we are, for the first time, on the eve of assembling for tactical manœuvers a fleet of sixteen battleships, which, thanks to the detail of gun-boats and small cruisers for police duty, can act as a school for flag and other officers in the very essentials and development of their profession. We have developed a system of auxiliaries and colliers, a docking and repair schedule, a target-practice schedule, and a base, I believe, unequalled anywhere for the necessary individual drill of a large number of ships; we have slowly and gradually convinced Congress of the need of coaling and repair stations which we are now building; naval thought has been directed toward naval problems, and the service has educated itself, and to some extent the people, as to our requirements. Naval drills and exercises have but one object—preparation for war; in short the entire tone of the service has changed in a few years.

The work involved in getting a large body under way is great; and while undoubtedly we have much to learn and far to go, the fact that inertia has been overcome, that the body moves, that a man must move with it or be cast aside, and that this has been done in a few years indicates to me that much progress has been made; and the results prove that we *have* men who in their respective grades can "drive," "manage," and "direct."

With all of his many paragraphs on the importance and necessity of preparation for war, the essayist singularly overlooks the necessity of

preparation for the tactical work which he states with such assurance is unsatisfactory. This preparation consists first in assembling a fleet (in this case it consisted in first building one), preparation of a suitable base (such as Guantanamo), arranging and working down to a practical basis a schedule for docking, repairs, etc., so as to leave the whole fleet uninterrupted for a considerable period, thus allowing the commander-in-chief and the individual ships time for the variegated drills in which both the fleet as a whole and the individual ships must become proficient. In his pessimistic attitude does he realize what has really been done with the ships which it has been possible for the navy department to assemble, or does he think only of what remains to be done? Is he accurately informed as to battle signals; as to range finding methods, and indeed, as to the value and importance of even going "ships right" accurately? Does he realize the importance of a ship being individually able to handle her guns, torpedoes, mines, and searchlights, before she can be really valuable in action? Does he realize the necessity of teaching a fleet to maintain accurate position in elementary manœuvers? In short, does his attitude do justice to the remarkable progress which has been made?

Thanks to those very leaders whose genius the essayist questions, we have now in the Atlantic a complete tactical fleet of battleships. Except those which have recently joined the flag, they are all well trained and efficient both individually and collectively. Tactical exercises of the highest importance have been held, the important problems of mobilization, maintenance, and methods of training have been solved, and with the coming battle-practice and the opportunity offered by a winter in Guantanamo of uninterrupted training and frequent practice in those advanced manœuvers, rendered possible by the increased size of the fleet, we can reasonably regard the outlook with much satisfaction.

Referring to his unfair analogies, it is a surprise to me that, with the unusual combination of business and naval experience possessed by the essayist, he so persistently compares the service to a business organization without finding room in the entire one hundred pages of his essay to suggest to those who might be reading hurriedly that this difference was chiefly due to the fact that the conditions differ materially; that the navy is run, not by one officer, nor by a board of officers, but by a civilian necessarily unfamiliar with many features, of short tenure in office, advised by various conflicting interests, subjected to political influences, and directly dependent in his plans, policies, and actions on the Naval Committee and either House of Congress. This is all necessary, but it seems unnecessary for him to wonder what it is which prevents the navy from developing like a commercial organization, and to attribute it to a lack of men who can manage and direct. Does he suppose that if any naval officer were "president" of an incorporated navy it would be run in all respects as at present? Does he suppose that had the commander-in-chief of the Atlantic Fleet been free to act he would have stopped the target practice of five new ships and have gone to the Jamestown Exposition voluntarily on April 15; that during the entire summer he would have kept ships lying there at anchor, or would have broken in on repairs and manœuvers to have ships attend an "unveiling," or would have done hundreds of other things

which directly interfere with preparation for war? These things are political; they interfere with efficiency but cannot be avoided. The essayist is not ignorant of the fact that these conditions exist; therefore, it is an unfair analogy which hurts the navy before the public, and is an unmerited criticism of those high in authority who are energetically devoting themselves and throwing the influence of their rank and experience towards our betterment.

And, is the attack upon the conservatism of the navy wholly merited? The criticism as a whole savors of the belief that the navy alone is conservative—ultraconservative—while no other body of men are. That it is not always true to an undue degree, the piles of material even now on the junk heap in each of our navy yards (impracticable devices, which have cost us immense sums), bear silent testimony. Except that I think we are all human beings, liable to err on either side, I might present examples to prove that we were sometinmes rather inclined the other way.

As for the telescope sight, the author is quite correct in saying that long after the Yorktown sight had been discredited, even as late as 1902, after ten years' experience with it (during which extended use it was doubtless greatly improved), many officers, of whom I was one (and incidentally Sims was another), agreed that the telescope than supplied was inferior to a good open sight. Can the service then be so seriously blamed because it refused to jump at the embryo which even ten years later (I have no hesitancy in saying) had not so developed as to render it superior to a good open sight? Of course some genius *might* have seen its possibilities and removed the defects which were inherent in all of the early designs. The inventor did not do this, but "Sims did it in 1904." This reminds me of wireless telegraphy. If the author remembers, injunctions were served in 1899 to prevent Marconi from using his wireless to report yacht races, owing to an infringement of patent. Then the ordinary public learned for the first time that wireless telegraphy was not new, but had been developed up to a range of two or more miles. Have we any record of business firms seizing, with avidity, this new and undeveloped means of communication? No! but they waited for a Marconi to render it practical.

As for submarine torpedo tubes, I had the honor to be affiliated with the group of officers who brought the subject up for reconsideration; yet when we consider the range of the torpedo at the time tubes were omitted, and the sacrifices required for their installation, I am forced to recognize that there were two sides to the question.

Was the navy ultraconservative in refusing to adopt the electric training system as installed on the *Brooklyn?* True, electric training has now been developed, but I imagine the board had before it the following systems: (a) Hydraulic; (b) Steam; (c) Pneumatic; (d) The proposed system as then developed, not as it now is. Now as late as two years ago I heard a large number of our most prominent and experienced gunnery officers expressing the belief that hydraulic power was superior to electric; in fact, I have heard this opinion from weighty sources recently; pneumatic versus even the improved electric system has, at the present moment, the backing of several officers of high standing (and might have more, except

that so few are familiar with it). Steam training is now entirely discredited; yet it is interesting to note that though this "ultraconservative" board reported "in toto" against the electric gear, which was actually installed on the *Brooklyn*, and though, for certain reasons, steam training (the least efficient of the three alternatives) was installed as its competitor, the reports of the record practice of the *Brooklyn* for 1904 (her last practice) show the score by 8-inch steam turrets 2.0 shots .8 hits, electric 2.0 shots .6 hits, per gun per minute. Therefore, though an implicit believer in the present electric training system, I must be permitted to question the "overwhelming superiority" of the electric system which was offered to this board for inspection, and to wonder from subsequent results if it was not perfectly sane in its adverse recommendation.

I wonder if the essayist simply doesn't know, or if he is wiping everyone aside for effect, when he says "not one officer of high rank helped Sims, but a civilian." Intended as a climax to the previous examples in support of his ultraconservative theories, it is indeed a fitting climax to his series of mistakes. Without entering into ancient history, I might ask if the essayist knew that in Sims' earliest reports Admiral Remey and Admiral Kempff, the two flag officers of the Asiatic Station, gave his papers the warmest support possible. Does he know that Admiral Evans, who was then squadron commander, began the present system of training in his squadron six months before Sims was ordered home from China, and that he held two target practices under that system before it was ever put in use on this side? Does he know that under Admiral Evans' direct encouragement the score of ten actual hits in two minutes was made on approximately our present target from a 5-inch gun, entirely without the assistance of any civilian? Does he know that the late and much lamented Rear Admiral H. C. Taylor was the best friend the new system ever had? Does he know that on Sims' return to the United States, Rear Admiral Higginson, then commander-in-chief of the North Atlantic Fleet, requested the chief of the Bureau of Navagation to order Sims down to the fleet to start the new system, and assisted in every possible way to set the training system in operation? Does he know of many, many others of somewhat less rank who assisted? Had he asked Sims he would have been so informed and would not have used such an ill-advised statement, to the discredit of such progressive officers, and as an example of ultraconservatism of the navy.

Captain E. B. BARRY, U. S. Navy.—The world produces few all-around men. Commander Fiske seems to have taken for his subject a restricted title, yet in his development of it he has endeavored with more or less success to touch upon about everything in the known civilized world.

His logic is not always good, for he seems at times to forget what he has written and contradicts himself. In one place he tells us "In the matter of self-development it is doubtful if any other vocation (than the naval profession) gives a man such excellent opportunities," while in another part of the essay he says, "Since we have always violated this principle ('the right man in the right place') can we wonder that we have on our hands so many ships that have eaten up our appropriations and our allowance of officers and men without adequate return?"

I think Commander Fiske starts with false premises. His introductory is admirable. Almost at the beginning he makes a statement fundamental to the navy, but which is lost in toto as the essay unfolds. "The naval profession exists only to wage naval warfare."

War is non-preventable except under one condition, sad to say improbable although possible. That condition is universal justice and morality. The histories of modern nations show a curious view of this very condition. While the opinion seems to be universal that individuals should be governed by principles of justice, nations should make their own principles. If a man steal a sum of money or a farm his fellow men condemn him as not "truly good"; but if a nation steals millions of dollars and miles of territory the world applauds, while the man that consummates it, who would turn in horror from stealing a penny, plumes himself on being an empire builder or some other high-sounding title as a national benefactor.

Exception must be taken to the remarks about the difficulties under which Von Moltke labored. "The government might have been republican and the same military proficiency have resulted, if the President had supported Von Moltke in his efforts the way King William did. The authority of a President, while not so autocratic over an entire country as is the authority of a King, is just as autocratic over the army and navy."

The late lamented Colonel James S. Pettit, U. S. A., in an able essay on this subject showed conclusively that this result never was and never can be attained by a republic. Prussia was a nation of soldiers in 1866, and the other German states became so after Königgratz. Does Commander Fiske imagine that any President of the United States could even order, much less enforce, the German military system in this country, without laws first passed by Congress? In the words of Patrick Henry, "Forbid it Heaven."

Why do we not manage modern fleets as well as they handled fleets in Nelson's day? The answer permeates the whole essay. To me the keynote is here. The scientific wail, and the specialistic wail are ever the same. We want to imitate Sir Joseph Porter, K. C. B., "Stick to your desk and never go to sea." Nelson and his contemporaries were sea officers. Are we?

The main idea advanced by the essay is that the naval establishment is an industrial one, like, for example, the Bethlehem works or R. H. Macy and Company. To me this is the false premise and it is the cause of most of the evils of which the essayist complains. A navy to be efficient, in my opinion, should be divided by a sharp line of demarkation into the supply branch and the using branch, in other words the industrial and the naval. It seems unfortunate the essayist made use of names to illustrate what the navy drove from its fold; it enables others to discuss and to differ. First and foremost did the navy lose navy officers? In spite of "golden years going sterilely by" but one of the persons named remained in the navy long enough after graduation to make any such discovery, and every one of them had openings offered him in non-naval and industrial life. They have become distinguished in their specialties as have many others that left the naval service. While illustrating every branch of commercial life from common scold to executive development, no representative of science was named, why was Michelson not included?

As far as my knowledge extends there have been but two officers driven out of the navy in forty years; the late lamented J. L. Stickney, through the arbitrary exercise of power by a man not fit to blacken Stickney's shoes, and Gilbert Wilkes, who was too sick to go to sea when his turn came. Evidently Wilkes had no "pull." I maintain all these men and lots of others not named have been of vastly more service to the navy out of it than in it, and entirely for the opposite reason than the one assigned by Commander Fiske; because they are commercial men and because the commercial side of the navy can be helped properly only from the outside. These men left the navy primarily to better themselves and because the navy offered them nothing from their point of view along their lines. Logically they became helps to the navy later, both by situation and by that love of Alma Mater implanted in the breast of every one of them.

It is a pity that the table showing the *principal* fleet actions of modern times should have left out MacDonough's victory on Lake Champlain. In skillful preparation and results it far outranks the dramatic battle on Lake Erie. These two battles are an indication of popularity as defined in our country. Probably there is not a child in the United States old enough to have studied our history who does not know all about Perry and his voyage from ship to ship, while I doubt if many of them ever heard the name of MacDonough. The battle of the Nile and the battle of Lake Champlain are very similar, except for the results. In each case a fleet at anchor was attacked. At Lake Champlain the disposition of the ships at anchor was such as to insure a decisive victory, and that victory was won by an inferior force.

Again and again have historians shown that civil authorities are the principal causes of defeat in war, but it makes no impression in the country concerned. Can anything be imagined comparable with the United States military and naval condition during the Jefferson administration? History may repeat itself.

Strategy is ably treated and many pertinent questions are asked. Under best method of promotion I think the author has gone again into commercial method and commercial success. Besides, these men were all specialists, the very thing we are told navy officers must not be, and they were exceptional men, mostly men of genius. No such organizations as these men built could be paralleled in army or navy. It is impossible to compare them. As well compare the navy with Tammany Hall.

The remarks about naval tactics are admirable, but I cannot agree with the author that the real reason an attack in column would be disastrous to-day is that the receiver of the attack has proportionately more gun power than the French had in Nelson's day. The English relied on bad shooting by their adversaries during the approach and good shooting by themselves after attaining close range. It would seem incredible that the heads of the English columns at Trafalgar were not crushed and destroyed long before they reached the enemy's line. Relative gun power could not account for a tremendous but harmless enfilading fire.

I wish I could accept the syllogisms about power and skill. If the strength of a fleet be doubled, the power of the admiral will not be doubled; the power *at the disposal* of the admiral will be doubled, but it

does not follow that a skill to handle eight ships can handle sixteen ships equally well. When you double the power, to make the skill equal in handling it, you must double the skill. This is all hairsplitting, as it really is adding two chairs to two chairs and calling them four tables—doubling mechanical products and comparing them with mental operations.

Without going into the details of the total want of mechanical ability and opposition to all change believed to be possessed by the majority of naval officers, I would call to mind that there still live persons outside the navy who believe that electric turret installation is not the best.

I think the author is a little out on the terrible example set by the case of Sims. We were using "ping pong" and working over sights on the Asiatic Station before Sims went home. Sims was out there then and I think Sir Percy Scott was also.

I repeat that the undercurrent of the whole essay to me is that the Navy is primarly an industrial establishment and in all its parts should be managed by such methods as built up the fortunes of A. T. Stewart, J. Gould, and the Standard Oil Magnates.

"Forbid it Heaven."

PROFESSIONAL NOTES.

Prepared by Professor PHILIP R. ALGER, U. S. Navy.

SHIPS OF WAR, BUDGETS, AND PERSONNEL.

AUSTRIA.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
Erzherzog Ferdinand-Max.	10,000	Trieste.	Under trial.
Ersatz Tegetthof	14,500	—	Projected.
Ersatz Kr.-Rudolf	14,500	—	"
Ersatz Kr.-Stephanie.....	14,500	—	"
Scout.			
Ersatz Zara	3,500	—	Projected.

The *Ferdinand-Max*, in her preliminary speed trials, made 19.57 knots mean speed with 14,390 horsepower. The other two ships of this class, *Erzherzog Karl* and *Friedrich* made 20.36 and 20.56 knots with 17,986 and 18,130 horsepower. respectively.—*Le Yacht.*

The Austro-Hungarian government have contracted with Messrs. Yarrow & Co., of Poplar and Glasgow, for the construction of two exceptionally high-speed shallow-draft gun-boats, propelled by internal combustion engines. These vessels are to be in all essential particulars similar to *Mercury II*, which was purchased by the British Admiralty last year.

Two Austrian submarines have been ordered in Germany. They will be of the same general type as *U*, but larger, as the displacement is about 300 tons. The horsepower will be 300, and the surface speed from 12 to 13 knots.—*Engineer.*

Two submarines of Holland type have been ordered from Vickers' Sons & Maxim, and two of Lake type are to be built in an Austrian port.—*Le Yacht.*

BRAZIL.

The battleship being built by Vickers' Sons & Maxim for Brazil will be named the *San Paulo.*

The torpedo-boat *Goyaz*, just completed by Messrs. Yarrow & Co. for the Brazilian Government, left Gravesend on September 4, for Brazil. The vessel is 152 feet 6 inches long, by 15 feet 3 inches beam, has a speed of 26½ knots and is propelled by turbines combined with a small triple expansion reciprocating engine, the latter being used for cruising on account of its superior economy at slow speeds. The *Goyaz* carries two 47-mm. quick-firing guns, and two 18-inch torpedo tubes. Her hull is of the Yarrow standard type for first-class torpedo-boats, being in all respects similar to 26 others that have been built for the Chilian, Austro-

Hungarian, Japanese and Dutch Governments, and to 20 others being built by Austro-Hungary.

FRANCE.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
Démocratie	14,865	Brest.	Under trial.
Justice	14,865	La Seyne.	" "
Vérité	14,865	Bordeaux.	Launched May 28, 1907.
Liberté	14,865	St. Nazaire.	Launched April 19, 1908.
Danton	18,350	Brest.	Ordered.
Mirabeau	18,350	Lorient.	"
Voltaire	18,350	Bordeaux.	"
Diderot	18,350	St. Nazaire.	"
Condorcet	18,350	"	"
Vergniaud	18,350	La Seyne.	"
Armored Cruisers.			
Ernest Rénan,	13,644	St. Nazaire.	Launched April 9, 1908.
Jules Michelet	12,550	Lorient.	" Aug. 31, 1908.
Edgard Quinet	13,644	Brest.	Launched Sept. 7, 1907.
Waldeck-Rousseau	13,644	Lorient.	"

THE VÉRITÉ.—The Société Anonyme des Chantiers et Ateliers de la Gironde, La Bastide-Bordeaux, launched in the presence of the Minister of Marine, on May 28, the battleship *Vérité*, the principal dimensions of which are:

Length between perpendiculars	133.8 m.	(439 ft.)
Main breadth	24.25 "	(79 ft. 6 in.)
Depth amidships	12.55 "	(41 ft.)
Draft:		
Forward	7.98 "	(26 ft. 2 in.)
Amidships	8.20 "	(26 " 11 ")
Aft	8.42 "	(27 " 7 ")
Area of amidship section	179.75 sq. m.	(1932 sq. ft.)
Displacement	14,870 tons.	

The sister-ships of the *Vérité* are the *Démocratie*, the *Justice*, and the *Liberté*. The four ships were included in the French Navy program for 1900; they were put down in 1902, but their construction was suspended during several months, under the Pelletan Ministry, with a view to cut down expenses, and to devote all available funds and the all the industrial facilities of the nation to the construction of smaller craft and submarine boats. The submarine craze is, therefore, largely responsible for the time taken in placing the four above-mentioned units on the list of ships available for active service.

The engines of the *Vérité*, built by Messrs. Schneider & Co., at their Creusot Works, are vertical, three-cylinder compound, three in number, each driving a propeller. They are mounted in three compartments, separated from each other by longitudinal water-tight bulkheads. They develop, including the accessory engines and feed-pumps, a total of 18,000 horsepower at 110 revolutions. Steam distribution is by Stephenson link motion and cylindrical valves:

Diameter of high-pressure cylinder	0.860 m.	(33 13/16 in.)
Diameter of intermediate cylinder	1.240 "	(49 in.)
Diameter of low-pressure cylinder	1.920 "	(76 ")
Stroke	1.150 "	(45¼ in.)

The boilers are of the Belleville type, and are 22 in number, their principal characteristics being:

Pressure	21 atm.	(308 lb. p. sq. in.)
Number of stokeholds	5	
Total grate area	127 sq. m.	(1,365 sq. ft.)
Total wetted heating surface	3600 "	(38,700 ")

The three propellers are four-bladed; the central and starboard propellers are left-handed, and the port one is right-handed. The central propeller is 4.8 meters (15 ft. 9 in.) in diameter, and the two lateral ones 5 meters (16 ft. 5 in.). The contract speed for the ship is 18 knots.

Her armament is to consist of four 305-millimeter (12-inch) guns, mounted in two turrets on the center line of the ship, one forward and one aft; ten 194-millimeter (7.63-inch) guns, six of which are mounted in six turrets for broadside firing, and four in four "blockhaus"; thirteen 65-millimeter (2.56-inch) quick-firing guns distributed over the 'tween deck; and ten 47-millimeter (1.85-inch) quick-firing guns on the bridges and in the fighting tops. There are, besides, two submarine torpedo-launching tubes for 450-millimeter (17.71-inch) torpedoes. The armament will include also six automobile and twenty automatic mechanical torpedoes.

She is protected by belt armor 280 millimeters (11 inches) thick at the center, tapering down to 180 millimeters (7 inches) at both ends of the ship; also by an upper deck of special steel 54 millimeters (2⅛ inches) thick, and by a lower deck, the horizontal plates of which are 51 millimeters (2 inches) thick, and those on the slant 70 millimeters (2¾ inches). The armor of the rotating turrets for the 305-millimeter (12-inch) guns is 280 millimeters (11 inches) thick, the 194-millimeter (7.63-inch) guns are protected by plates 200 millimeters (7.87 inches) in thickness; the "blockhaus" plates are 300 millimeters (11.81 inches) thick.—*Engineering.*

The launching of the *Vérité* at Bordeaux was something of an event in naval annals. She had all her boilers and machinery on board, all three funnels up, the lower parts of both masts, most of her armor in position, including the big gun turrets minus the guns, and the secondary turrets with the guns installed. The launching weight was close upon 12,000 tons—that is, within 3000 tons of the total displacement—and we believe this constitutes a record. She was launched from a slip, not floated out of a dry dock.—*Engineering.*

All three cruisers of the *Gambetta* class have now done their "reliability trials." The results are as follows: *Victor Hugo*, 96 hours—average, 19.5 knots; *Jules Ferry*, 72 hours—average, 20 knots; *Léon Gambetta*, 24 hours—average, 19 knots. At the end of 24 hours the *Gambetta* did a couple of hours at full speed, and made 22 knots.

The *Jules Michelet*, the last of the *Gambetta* class, is nearly ready for trial. She differs from her sisters in having four 16.5-cm. guns less than they.—*Engineer.*

The French battleship *Patrie* recently burned her funnels out. According to the semi-official *Moniteur de la Flotte*, Messrs. Niclausse will have to pay for this. Were a similar rule enforced in this country, some boilermakers would find Admiralty contracts far from profitable, as funnels burned out more or less are by no means uncommon now-a-days after hard steaming bouts.—*Engineer.*

Le Yacht states that the displacement of the *Waldeck-Rousseau* will be 14,300 tons; her horsepower, 40,000; speed, 24 knots, and battery, fourteen 19.4 cm. (10 in turrets with 8-inch armor and 4 in casemates with 4.7-inch armor) and twenty 6.5-cm. guns.

The *Democratie* on her full-power trial at 18,000 horsepower worked up as high as 19,190 indicated horsepower, and reached a speed of 19.4 knots. The 24 hours' trial at 10,500 horsepower resulted in a mean of 11,472 indicated horsepower, and a mean speed of 17.35 knots. The *Democratie* is fitted with the new type of Bellevilles, with the economisers low down instead of up in the funnels.—*Engineer.*

On the completion of the maneuvers the ships of the French fleet began to execute the recent ministerial orders looking to the redisposition and renewal of their powder. When this work is finished, early in September, the great majority of the powders afloat will be A. M. and the oldest indices will date from 1902. Moreover a long step will have been taken towards the unification of lots.

The new series of large submersibles, hitherto designated *Q51, Q52*, etc., are to be named after the months of the revolutionary calendar—*Pluviôse, Ventôse, Germinal, Floréal, Prairial, Messidor, Thermidor, Fructidor, Vendémiaire, Brumaire, Frimaire, and Nivôse.* This series goes from *Q51 to Q63* inclusive, excepting *Q61* which is a very small boat which has not been completed.—*Le Yacht.*

The Cherbourg correspondent of the *Yacht* refers to the launching of the submarine *Rubis*, which is of the *Emeraude* type designed by M. Maugas, and displaces 400 tons, with a length of 154 feet 3 inches, and of the *Q51* on the same day, June 27. The latter boat belongs to a series of six, *Q51* to *Q56*, 450 tons, 167 feet 5 inches, designed by M. Laubeuf. According to the correspondent, these boats will have four torpedo tubes, but in a table added by M. Laubeuf to his paper on submarines read before the Naval Architects' Congress at Bordeaux, he shows a bow tube and six discharges on the broadsides. There is probably an error here, because in his paper M. Laubeuf remarked upon the danger of bow tubes, and said that if the *Bonite* had had such a tube when she came into collision with the *Suffren* February 5, 1906, she would have been destroyed. The correspondent of the *Yacht* remarks that, with the two new types of vessels, comparative trials will take place, which will be more interesting than those between the *Aigrette* (M. Laubeuf) and the "*Z*" (M. Maugas), wherein the former boat was the more successful. The submarines have lately been in difficulties, though without serious injury. The *Sirène* was in collision with the *Henry IV*, the *Français* with the yacht *Velox*, and the *Morse* and *Algérien* with other vessels.—*Army & Navy Gazette.*

MOTOR TORPEDO-BOAT.—European naval experts are greatly interested in a small motor torpedo-boat displacing eight tons only, which has been built for the French navy for experimental purposes. This little craft has been constructed at the Petit Quevilly, near Rouen, and ascended the Seine at a speed of 14 knots. Her upper works are of steel, and include water-tight compartments for safety. The whole boat is constructed of thin steel, and has a motor of the Cazes type, developing 170 horsepower with 900 revolutions and 150 horsepower with 800 revolutions. The motor drives a reversible screw as well as the auxiliary machinery. The boat attained a speed at her trials of 16.3 knots. She has a torpedo tube in the bow, and it is said that she can be navigated and worked by two men. She is 52 feet 5 inches long, 8 feet 9 inches beam, and 3 feet extreme draft.—*Nautical Gazette.*

GERMANY.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
Pommern	13,200	Stettin.	Under trial.
Hannover	13,200	Danzig (Schichau Works).	" "
Schleswig-Holstein	13,200	Kiel.	Launched Dec. 17, 1906.
Schlesien	13,200	Danzig.	" May 28, 1906.
Ersatz Bayern	19,000	Wilhelmshaven.	Building.
" Sachsen	19,000	Bremen.	"
" Würtemberg	19,000	Stettin	"

Name.	Displacement.	Where Building.	Remarks.
Ersatz Baden	19,000	(Vulcan Works). Kiel (Germania Works).	Building.
Armored Cruisers.			
Gneisenau	11,600	Bremen.	Launched June 14, 1906.
Scharnhorst	11,600	Hamburg.	Under trial.
E	15,000	Kiel.	Building.
F	18,000?	Bremen.	"
Protected Cruisers.			
Stuttgart	3,420	Danzig.	Launched Sept. 22, 1906.
Stettin	3,420	Stettin.	" March 7, 1907.
Nürnberg	3,420	Kiel.	" Aug. 28, 1906.
Ersatz Pfeil	3,500	Danzig.	Building.
" Komet	3,500	Hamburg.	"
" Greif	3,500?	——	Authorized.
" Jagd	3,500?	——	"

THE NEW CRUISERS.—The armored cruiser *F* is to cost 36,500,000 marks as against 27,500,000 marks for *E*. The cruisers *Ersatz Grief* and *Jagd* are also to be larger and more costly than their predecessors. It is believed to be finally settled that all the new cruisers as well as the new battleships will be fitted with turbines.

THE ESTIMATES FOR 1907.—The estimates for 1907 amount to 278,528,891 marks (£13,926,444 11s.), as against 253,456,685 marks (£12,672,384 5s.) voted for 1906, showing an increase of 25,072,206 marks (£1,253,610 6s.). The following are the principal items:

Ordinary Permanent Estimates.

	Proposed for 1907. £	s.	Voted, 1906. £	s.
Imperial Ministry of Marine and Naval Cabinet	94,927	0	89,660	10
Naval headquarter staff	15,466	15	16,603	0
Observatories, etc.	18,326	14	17,819	4
Station Accounts Department	30,897	18	28,945	0
Legal Department	8,516	0	8,440	0
Chaplains' Department and Garrison Schools	6,990	15	6,753	16
Pay of officers and men	1,451,533	15	1,350,904	12
Maintenance of fleet in commission	1,559,858	0	1,431,523	0
Allowances for officers and men	108,818	14	103,265	4
Clothing	22,014	3	20,617	18
Barrack and garrison administration, etc.	48,119	10	74,662	15
Barrack and garrison construction	33,466	14	.....	
Lodging allowance	127,852	17	119,518	0
Medical Department	115,886	18	105,592	17
Travelling, transport, and freight charges	170,550	0	172,300	0
Training establishments	24,627	17	20,249	17
Maintenance of fleet and dockyards	1,478,923	10	1,403,135	14
Ordnance, arms, and fortification	559,684	18	515,942	8
Accountant-General's Department	46,033	7	43,664	10
Pilotage and surveying	36,549	0	35,464	16
Miscellaneous expenses	18,069	1	74,944	5
Administration of Kiau-Chau protectorate	5,195	15	5,107	7
Total	6,042,309	1	5,645,114	3

Special Ordinary Estimates.

Shipbuilding Program for 1907.

For the construction of the following ships:

	£	s.
The first-class battleship *Pommern* (*O*), 4th and final vote	117,500	0
" " " *Hannover* (*P*), " " " "	117,500	0

	£ s.
The first-class battleship *Q*, 3d vote	232,500 0
" " " *Schlesien* (*R*), 3d vote	232,500 0
" " " Ersatz *Bayern*, 2d vote	430,000 0
" " " Ersatz *Sachsen*, 2d vote	430,000 0
The first-class armored cruiser *Gneisenau* (*C*), 4th and final vote	75,000 0
" " " " *Scharnhorst*, 3d vote	213,500 0
" " " " *E*, 2d vote	300,000 0
For the construction of:	
The third-class cruiser *Stuttgart* (*O*), 3d and final vote	54,500 0
" " " Ersatz *Wacht*, 3d and final vote	54,500 0
" " " *Nürnberg*, 3d and final vote	54,500 0
" " " Ersatz *Pfeil*, 2d vote	121,500 0
" " " Ersatz *Comet*, 2d vote	121,500 0
Mine-ship *B*, 2d and last vote	50,000 0
A flotilla of torpedo-boats, 2d and last vote	320,000 0
One flotilla of torpedo-boats, 1st vote	400,000 0
Tender Ersatz *Ulan*	25,000 0
Battleship Ersatz *Württemberg*, 1st vote	150,000 0
" Ersatz *Baden*, 1st vote	150,000 0
First-class cruiser *F*, 1st vote	150,000 0
Third-class cruiser Ersatz *Greif*	75,000 0
" " Ersatz *Jagd*	75,000 0
Fitting up battleship *König Wilhelm* as a volunteer drill ship, 1st vote	20,000 0
Construction of sailing yacht Ersatz *Wille*	1,500 0
Repairs and alterations to first-class battleship *Hansa*, 1st vote	37,500 0
Improvements to the first-class armored cruisers *Hertha* and *Victoria Louise*, 2d and last vote	125,000 0
Construction of and experiments with submarines	150,000 0
Total	4,294,000 0
For the gun and torpedo armaments of new ships, and mines	2,129,500 0
Miscellaneous expenditure: dockyards, etc	351,907 10
	6,819,622 10
From which has to be deducted, credited in the extraordinary estimates	1,804,000 0
Leaving total	5,015,622 10

Summary.

	1907. £ s.	1906 £ s.	Increase, 1907. £ s.
Ordinary permanent estimates	6,042,309 1	5,640,101 15	402,207 6
Shipbuilding, armament, etc.	5,015,622 10	4,434,482 10	581,140 0
Extraordinary expenditure	2,368,513 0	2,598,250 0	270,263 0
Totals	13,926,444 11	12,672,834 5	1,253,610 6

The five battleships of the *Kaiser* class (*Barbarossa*, *Friedrich III*, *Wilhelm II*, *Wilhelm-der-Grosse*, and *Karl-der-Grosse*) are to be rebuilt and rearmed. The work has been begun on the *Kaiser-Barbarossa*.—*Moniteur de la Flotte*.

The German cruiser *Koenigsberg* on her full power trials realized I. H. P. 13,918 and 24.1 knots. These results were well over contract.—*Engineer*.

The construction of submarine boats has recently been taken up by German shipbuilders, and after a series of trials on a small model boat, the

Germania shipyards at Kiel have just completed a large submarine of 240 tons. The main dimensions of this vessel are: Length over all, 137.5 feet; maximum width across frames, 11.7 feet; draft of boat when emerged 7.8 feet. An electric motor and gas engine, each with an output of 200 indicated horsepower, are fitted to each of the two propeller shafts, the propeller being adjusted from the inside of the vessel. The electric motors are designed for propulsion below water, and receive current from an accumulator battery installed amidships. The battery is sufficient to drive the boat below water for fully three hours at its maximum speed of 9 knots. When on the surface, the gas engines are preferably to be used. The fuel is carried in tanks, arranged outside of the boat (according to patents of the Germania shipyards) thus guarding against explosion. The store carried by the submarine enables the latter to cover a distance of 1000 knots at her maximum speed of 11 knots on the surface.

The motors can obviously be used also for propulsion above water, while both types of motor can also be used simultaneously for the propulsion of the vessel.

THE BOAT SUBMERGED AND TRAVELING AT FULL SPEED.

The submersion and emersion of the boat is effected by filling and discharging the ballast tanks arranged inside, as well as by the aid of two pairs of horizontal rudders. The maximum admissible depth of submersion has been fixed at about 120 feet. Only five minutes are required to prepare for submerging the boat.

Special care has been bestowed on ventilation, which is secured by an electrically operated ventilator, which, as long as the boat is above water, will constantly supply all the rooms with fresh air. When submerged, the vitiated air is passed through a cleaning tank, after which it returns toward the various compartments of the boat. With a crew of 10 men the vessel is able to sail under water for periods up to 24 hours.

The armored conning-tower arranged in the center of the boat and inclosing all necessary instruments, such as viewing apparatus, manometers, rudders, and telephones, is large enough readily to accommodate the commander and the pilot. Two periscopes have been provided, which, both in a vertical and horizontal direction, cover a field of 50 degrees. The length of these inclosing telescopic tubes has been chosen with a view to allow the boat to travel at a depth sufficient to warrant it against gun fire, while still enabling it to cover the whole of the horizon.

The armament of the submarine comprises an 18-inch bow torpedo-launching tube. One of the three large-sized torpedoes carried by the vessel is contained in the tube, while the two remaining ones are arranged in water-tight reservoirs.

Trial runs performed in Eckernförde Bay, both in the emerged and sub-

merged condition, have demonstrated the satisfactory sea-going qualities of the submarine.—*Scientific American.*

A new German torpedo-boat known as *G 137* had her first speed trial at Eckernförde Bay July 30, and developed a speed of 32 knots an hour, as against the 30 knots called for in her contract. She was built by the Krupps in the Germania yard at Kiel, and is fitted with turbine engines and is the largest torpedo-boat in the German Navy, being about 50 tons larger than any other boat of this class. Provisions for the construction of boats of this size were adopted by the naval authorities in 1906, and *G 137* is the first of the new vessels.—*Nautical Gazette.*

With the launching of the *Schlesien* and *Schleswig-Holstein* there are 24 battleships afloat, having each a displacement of from 10,000 to 13,200 tons. A new period in naval construction will now begin, in which the displacement will be increased to 18,000 tons, and the armament will be completely altered. This is expected to increase the cost of building each ship from 24,250,000 marks (£1,212,500) to 36,500,000 marks (£1,825,000). The 24 battleships just mentioned constitute the total output in battleships during the present emperor's reign. Of the number, 18 have been built in private yards and only 6 in government yards—a distribution of the work which has had the effect of increasing the number of workmen employed in private yards from 20,400 men in 1890 to 41,300 at present. Simultaneously, the productive capacity of German shipbuilding yards has become greater, for whereas the construction of a ship of the *Brandenburg* class, with a displacement of 10,000 tons, took from three to four years in the early '90's, the *Deutschland,* which has a displacement of 13,200 tons, has taken only three years to complete.

The German Admiralty is resolved that, in addition to the Kaiser Wilhelm Canal between the North Sea and the Baltic, other waterways shall be available for use by shallow-draft craft, and for this purpose the waters referred to are being tested by torpedo-boats, which are passing repeatedly through the Elbe and Trave Canal and the old Schleswig-Holstein Canal, which is a continuation of the North Sea and Baltic Canal between Rendsburg and Tönning at the mouth of the Eider.

Motor boats are being used more and more as tenders for waiting on the war-ships and torpedo-boats. They travel at the rate of 20 knots.

The German Admiralty has begun to build the projected naval school at Mürwik, on the Flensburg Fiord. This school, which is to cost £100,000, is to be finished by the spring of 1908, when it will be occupied by the naval cadets of 1907, on their return from foreign waters. Next year the latest enrolled cadets and the cadet division will be transferred from Kiel and the Kiel forts to Mürwik.

DOCKING ACCOMMODATION AT THE DISPOSAL OF THE GERMAN FLEET.—The largest floating dock in the world is at Hamburg, at the building yard of Messrs. Blohm & Vose. It can lift ships of a displacement of 22,500 tons, and is 756 feet long, with a beam of 88 feet 6 inches. This yard also possesses three other docks capable of taking in vessels of 17,500 tons, 4500 tons, and 30000 tons respectively.

The capacity of 22,500 tons of the first dock is obtained by joining a section of the 17,500-ton dock, called the "Elb" dock, with a 17,000-ton pontoon-dock. This dock is constructed in such a manner that its working is independent; it is provided with a central and auxiliary engine, so that in case of war it can be at once towed towards the mouth of the Elbe.

The Reiherstieg Yard possesses two docks capable of lifting two ships of 11,500 and 5000 tons respectively. The Brandenberg and Stulken Yards also possess two good docks, that of the first being able to take in vessels of 7200 tons, and of the latter, vessels of 7000 tons. The largest graving dock belongs to the Hamburg-American Line; it is 400 feet long, with a beam of 60 feet 6 inches; but another dock, 700 feet long, is under con-

struction. The firm of Blohm & Voss are construction a new dock, which is to be able to take in a vessel of 35,000 tons, and at the Vulcan Yard at Stettin, two very large new docks are being constructed. The dock at Bremen, which is leased by the town to the Norddeutscher Lloyd Co., can compare with the largest docks in England, being 760 feet long, with a breadth of 108 feet. The graving docks at Kiel, with a length of 594 feet and a breadth of 95 feet 3 inches, can take in vessels of the dimensions of the *Dreadnought*. The docks at Wilhelmshaven have a similar capacity.

Germany possesses, in addition, some other large docks: that of the Seebeck Yard, at Geestemunde (525 feet long); the Vulcan Yard, at Stettin, which is 510 feet long, and will take in a vessel of 12,000 tons; that of the Weser Yard, which will take in a vessel of 11,000 tons; and two belonging to the Norddeutscher Lloyd, 576 feet and 380 feet long respectively.—*United Service Institution.*

GREAT BRITAIN.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
Bellerophon	18,550	Portsmouth.	Launched July 27, 1907.
Téméraire	18,550	Devonport.	" Aug. 24, 1907.
Superb	18,550	Newcastle.	Building.
Lord Nelson	16,500	Jarrow (Palmer).	Launched Sept. 4, 1906.
Agamemnon	16,500	Glasgow (Beardmore).	Under trial.
Armored Cruisers.			
Minotaur	14,600	Devonport.	Launched June 6, 1906.
Shannon	14,600	Chatham.	" Sept. 20, 1906.
Defence	14,600	Pembroke.	" Apr. 27, 1907.
Invincible	17,250	Newcastle.	" Apr. 13, 1907.
Inflexible	17,250	Clydebank.	" June 26, 1907.
Indomitable	17,250	Glasgow.	" Mar. 16, 1907.
Cruiser.			
Boadicea	3,300	Pembroke.	Building.

THE NEW BRITISH BATTLESHIPS.—In the two battleships which are to be laid down in accordance with the current year's program, a departure from the policy adopted in regard to the armament of the *Dreadnought* is to be effected. While of the same class and type, they will be 2000 tons heavier, their displacement being about 20,000 tons. In regard to the main armament, there will not be so many weapons of the larger caliber, though they will be much heavier, a new 13.5-inch weapon which has been severely tested being adopted in the place of the 12-inch. This gun fires a shell weighing 1250 pounds as compared with the 850-pound shell of the 12-inch arm. Moreover, a secondary battery of medium quick-firing guns is to be carried, a feature which is entirely absent in the *Dreadnought*, and which deficiency has been severely criticised. The effect of this modification will be that the new vessels will have an aggregate broadside fire of some 8500 pounds as compared with 6800 pounds in the *Dreadnought*. These two vessels are to be laid down at once at the Portsmouth and Devonport dockyards respectively, and they will each cost over ten million dollars. At the present time the armament firms in the country are working at full pressure to deliver the present order of 12-inch guns for the navy's immediate requirements, no less than 120 of these weapons being in course of construction.—*Scientific American.*

It is understood that three more battleships of an improved *Dreadnought* type will be commenced at an early date, the fate of the third vessel having been decided by the assured failure of the Hague Congress to come to an agreement for the limitation of armaments.

Preparations are already well advanced at Portsmouth for the laying down of the keel-plates of the first of these men-of-war on the slip recently vacated by the Bellerophon, and the second will be begun at Devonport about a month later, while the third—the construction of which has been problematical pending the result of the Peace Conference—will be built by a private firm.—*Page's Weekly.*

ABSTRACT OF NAVY ESTIMATES FOR 1907-1908.

Votes.		Estimates, 1907-1908.			Estimates, 1906-1907.		
		Gross Estimate.	Appropriations in Aid.	Net Estimate.	Gross Estimate.	Appropriations in Aid.	Net Estimate.
	I.—Numbers.						
A	Total number of Officers, Seamen, Boys, Coastguard, and Royal Marines	128,000	.....	Total Numbers. 128,000	129,000	.....	Total Numbers. 129,000
	II.—Effective Services.						
1	Wages, etc., of Officers, Seamen, and Boys, Coastguard, and Royal Marines	£ 7,006,412	£ 136,742	£ 6,869,700	£ 6,946,527	£ 135,827	£ 6,810,700
2	Victualling and Clothing for the Navy	2,441,217	444,817	1,996,400	2,582,099	528,899	2,053,200
3	Medical Establishments and Services	287,856	19,156	268,700	294,797	19,297	275,500
4	Martial Law	14,295	95	14,200	14,795	95	14,700
5	Educational Services	236,831	64,331	172,500	229,461	63,861	165,600
6	Scientific Services	90,280	25,180	65,100	90,193	25,093	65,100
7	Royal Naval Reserves	426,518	8,218	418,300	434,761	8,161	426,600
8	Shipbuilding, Repairs, Maintenance, etc.: Section I.—Personnel	2,571,700	21,800	2,549,900	2,429,400	21,800	2,407,600
	Section II.—Matériel	3,420,200	385,000	3,035,200	3,355,200	528,000	2,827,200
	Section III.—Contract Work	7,783,000	137,000	7,646,000	8,725,400	137,000	8,588,400
9	Naval Armaments	2,508,700	160,000	2,348,700	3,135,123	149,123	2,986,000
10	Works, Buildings, and Repairs at Home and Abroad	2,792,400	34,000	2,758,400	1,986,500	32,000	1,954,500
11	Miscellaneous Effective Services	414,437	13,437	401,000	495,090	12,890	482,200
12	Admiralty Office	373,350	8,750	364,600	360,250	8,750	351,500
	Total Effective Services	30,367,196	1,458,496	28,908,700	31,079,596	1,670,797	29,408,800
	III.—Non-Effective Services.						
13	Half-pay, Reserved, and Retired Pay	850,775	12,875	837,900	893,580	12,880	880,700
14	Naval and Marine Pensions, Gratuities, and Compassionate Allowances	1,321,745	19,745	1,302,000	1,276,028	19,728	1,256,300
15	Civil Pensions and Gratuities	371,330	430	370,909	384,098	398	383,700
	Total Non-Effective Services	2,543,850	33,050	2,510,800	2,493,706	33,006	2,460,700
	Grand Total	32,911,046	1,491,546	31,419,500	33,573,302	1,703,803	31,869,500

NOTE.—Provision to the extent of £977,091 is included in the Estimates for 1907-1908 under Votes 8, 10 and 12, for the continuation of services hitherto provided for out of funds raised under the authority of the Naval Works Acts, 1895 to 1903.—*United Service Institution.*

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It is stated on good authority that the Admiralty's next shipbuilding program will include the laying down of a new type of armored cruiser at Pembroke Dockyard during 1908-9. Although small warships have been sold out of the Service on the ground that their limited fighting value did not justify the expenditure on maintenance, the recent earthquake in Jamaica and the riot at St. Lucia, during both of which no British warship was immediately available for aid, have convinced the Admiralty that a new class of ship of appreciable fighting power, suitable for detached police duties and for periodically visiting remote stations, is necessary. The new vessel will, therefore, be intermediate in size between a second-class cruiser and the ships of the *Duke of Edinburgh* class. She will be protected by side armor, will mount 7.5-inch guns, and will have a speed of 23 knots per hour.—*United Service Gazette.*

The new battleship *Bellerophon*, a sister-ship to the *Dreadnought*, was successfully launched at Portsmouth on July 24. The *Bellerophon* is an improved *Dreadnought*, and will include many of those improvements which have been found to be necessary during the recent trials of the *Dreadnought*. The new ship will have a greater displacement than her predecessor on the building slip, the *Dreadnought's* tonnage being 17,900 tons, whereas the *Bellerophon*, when completed, will displace 18,600 tons. The length and beam are identical with the older ship, 490 feet and 82 feet, respectively. Uncertainty prevails as to the armament of the new vessel, but there is a general impression that her main armament will be the same as the *Dreadnought*—ten 12-inch guns—with the addition of 4-inch guns in the place of the 12-pounders carried by the *Dreadnought* for repelling torpedo attack. The new vessel will have turbine engines, and the shafts for the four propellers have been already drilled. In every other respect the *Bellerophon* will be like the *Dreadnought*. The launching weight of the new ship was 7000 tons. The first keel plate was laid on December 3, so that eight months have been taken in reaching the launching stage. The engines are by the Fairfield Company, and the vessel will have a speed of 21 knots.—*United Service Gazette.*

The *Bellerophon* and her sisters should be improvements on the *Dreadnought*, the experience gained with that vessel having been utilized in their construction and equipment. The displacement is increased by 700 tons, but how exactly this extra weight will be used has not been officially revealed. It is believed, however, that it will be partly absorbed in constructional re-arrangement, including the raising of the middle turret on the center line to a level with that of the forecastle turret. There will also be an improvement in the anti-torpedo defence armament, a new 4-inch gun being substituted for the 12-pounders of the *Dreadnought*. This alteration will most likely require a redistribution of this battery. It has also been suggested that the armored belt may be carried higher up the side of the ship, because if nothing in this direction is done the belt will most likely, with the increased displacement, be below water when the ship is fully laden. These vessels should be easily completed for sea by the end of next year, and thus enable us with the *Invincibles* and *Lord Nelsons* to have a fleet of eight ships absolutely unrivalled or approached by any other naval power.—*Army and Navy Gazette.*

England's third battleship of the *Dreadnought* class, the *Temeraire*, was successfully launched August 24, at Devonport. She is the heaviest warship ever launched from a royal dockyard. Her launching weight was 7475 tons, which is 500 tons heavier than the *Bellerophon*. The *Temeraire* will mount ten 12-inch guns, the same as the *Dreadnought*. Four-inch guns have been substituted for the *Dreadnought's* 12-pounders for repelling torpedo-boat attacks.

She is the fifth of her name in the British Navy.

THE ELECTRIC OUTFIT OF THE DREADNOUGHT.—The electric outfit of the *Dreadnought* is unusually complete. At the top of the foremast, and immediately above the forward funnel, is the fire control platform, upon which are placed the range finders, for locating the position of an enemy or target at sea. In the turrets and on this platform is installed a new automatic system of range finding and gun elevating, by means of which the range as read will be electrically transmitted to each gun position, where, by the use of synchronized motors, the elevation of the guns will be steadily and continuously changed to correspond with the increasing or decreasing range, as recorded by the range finder on the platform. This method is said to remove all possibility of error in the transmission of information as to the ranges and in the manual elevation of the guns, and leaves to the gun crew merely the duty of traversing the guns, and thus keeping them fixed upon the enemy. The lofty foretopmast places the fore truck fully 200 feet above the water line. A short mainmast is carried in the usual position, mainly for the support of the antennæ of the wireless telegraph equipment.—*Iron Age.*

NAVAL QUESTIONS IN THE HOUSE OF COMMONS.

BRITISH AND GERMAN SHIPBUILDING PROGRAMS.—Mr. E. Robertson, having been asked to what years program the armored cruisers *Minotaur, Shannon, Defence, Achilles, Cochrane, Natal,* and *Warrior* belonged; on what dates they were laid down; on what dates they were, or would be completed; and what time was occupied in building them, replied as follows (the dates marked with asterisks being as estimated):

Ship.	Program.	Date laid down.	Date completed.	Time occupied in building. Yrs.	Mths.
Minotaur	1904-5	Jan. 2, 1905	*Feb., 1908	3	1
Shannon	Do.	Jan. 2, 1905	*Feb., 1908	3	1
Defence	Do.	Feb. 22, 1905	*Dec., 1908	3	10
Achilles	1903-4	Feb. 22, 1904	Mar., 1907	3	1
Cochrane	Do.	Mar. 24, 1904	Feb., 1907	2	11
Natal	Do.	Jan. 6, 1904	Apr., 1907	3	3
Warrior	Do.	Nov. 5, 1903	May, 1907	3	6

It was then asked to what year's program the German armored cruisers *Gneisenau, Scharnhorst, Roon,* and *Yorck* belonged; on what dates they were laid down; on what dates they were completed; and what time was occupied in building them. The following information was given:

Ship.	Program.	Date laid down.	Date completed.	Time occupied in building. Yrs.	Mths.
Gneisenau	1904-5	June, 1904 (launched June 14, 1906).	Not yet completed.	..	..
Scharnhorst	1905-6	May, 1905 (launched March 22, 1906.)	Do.	..	..
Roon	1902-3	Aug. 1, 1902	Oct., 1905	3	2
Yorck	1903-4	April 25, 1903	Nov., 1905	2	7

THE NAVY ESTIMATES.—Mr. E. Robertson, in submitting the vote of £2,549,900 for naval establishments and dockyard and naval yards at home and abroad, announced the decision of the Admiralty as to supplying cooling appliances to the magazines in which cordite was stored on board ships, and as to testing the cordite. The expenditure involved in the present financial year would be £200,000. Dealing with the shipbuilding program, he said: "The Board of Admiralty did not recognize in the case of destroyers any hard-and-fast age limit. This year they would build five ocean-going destroyers, and 12 turbine-engined torpedo-boats. Count-

ing coastal destroyers, France had 65, Germany 83, and Great Britain, 191. The British fleet of destroyers was on the whole superior in essential qualities to those of other powers. The total sum which was being spent on new construction was £8,100,000, and of this £2,800,000 was for cruisers. First of all came the vessels of the *Invincible* type. Each of these would cost £1,720,000. There were to be three cruisers of the *Minotaur* type, each of which would cost £1,400,000. Then there were to be four cruisers of the *Warrior* class, costing £1,200,000. The *Boadicea*—a new departure—laid down at Pembroke early in the financial year, would cost £350,000. As to repairs of ships, in the last year of the previous government, the amount set aside for repairs was £1,628,000; the present government increased that by £282,000. In the present year the estimate was £1,888,000, and up to date they had over-spent to the extent of £44,000. The officers responsible for repairs in the navy reported that the fleets in commission, fully manned, were in excellent condition.

OFFICERS' MESS EXPENSES.—Mr. Robertson stated that the average cost per head borne by officers in the navy for their daily messing and the expenses of servants and upkeep of the mess was prescribed by the King's Regulations as follows: In the ward-room, the monthly mess subscription is not to exceed £3. In the gun-room, the monthly mess subscription is not to exceed 30s.; but in addition to this sum 5s. may be charged for replacing mess utensils and other necessary expenses; and the following sums may also be allowed for extras, should a member choose to indulge in them—namely, for commissioned officers, £1 a month; for other members, 10s. a month. Each ward-room officer entitled to the services of a marine servant is required to pay the sum of 10s. a month to the man employed; if the services of the man are shared with another officer, each officer is required to pay the sum of 6s. a month to the man. The average value of rations provided for officers in the navy at the public cost is 10d. per diem. The whole cost of naval ratings of cooks and waiters required to keep up the officers' messing is provided at the public expense.

MOBILIZATION OF THE HOME FLEET.—Mr. E. Robertson, answering Mr. Gretton, who asked if official notification was given to the home fleet 12 days before the date of the recent mobilization, and when the Admiralty tested the instant readiness for war of this fleet, as at present organized, by a surprise mobilization, said that no surprise mobilization had been carried out since last year. That was entirely satisfactory, and the conditions were now more favorable.

THE ADMIRALTY AND THE TRIAL OF OFFICERS.—Mr. Robertson, replying to Mr. Bellairs, who asked whether it was the established practice of the navy to hold a public court-martial on every officer who lost or surrendered his ship; and, if so, whether he could state why this rule had not been enforced in the case of the *Ariel*, lost on Malta breakwater on April 19, said that the practice was usual, but not invariable. Where all the facts had been brought out by a court of inquiry, as in that case, the Admiralty had power to deal with it directly without further trial. The officer in question was censured.

ORDERS FOR SUBMARINES.—Mr. E. Robertson informed Mr. G. D. Faber that seven submarines had been ordered from Messrs. Vickers, and in addition two had been commenced at Chatham since the present government came into office. In accordance with the practice of successive Boards of Admiralty in regard to this class of vessel, and continued after due consideration by the present board, no competitive tenders were obtained.

To Mr. Faber, who wished to know whether the cost of submarines was not increased by the system of secret contracts with private firms, Mr.

Robertson said the Admiralty were testing that by competition with the dockyards.—*United Service Gazette.*

High topgallant masts for the new type of "wireless" are to be fitted to all modern British warships.—*Engineer.*

Since Lord Charles Beresford issued an order to the Channel fleet, regretting the disuse of the boatswain's pipe as a medium for conveying naval commands, the Admiralty, having had under consideration the best means of retaining the use of this time-honored instrument, have directed that 10 per cent of boys in training establishments are to be instructed in such familiar and traditional calls as the following: Call hands, lash up and stow, reelers, heave round capstan, walk back capstan, haul taut, hoist away, high enough, pipe dinner, pipe down, pipe side, call away boat, call away galley, stand by wash clothes, and sweepers. In order to encourage the boys a prize is to be awarded out of the Boys' Fund each half-year.—*United Service Gazette.*

An Admiralty order has been received at Pembroke dockyard directing the installation of a new system of ventilation in the magazines of all British warships, whether in commission or building. The new system provides for the utilization of carbonic acid gas for the purpose of keeping the temperature of the magazines at all times below 70 degrees F., and the order directs that estimates are to be prepared for fitting the installation into all ships at Royal dockyards.—*United Service Gazette.*

No less than three accidents to destroyers were reported during the week ending July 13. The *Mallard* went ashore at Lefkimo, on the coast of Corfu, on the 9th inst., but was subsequently got off and towed to Malta in a damaged condition. The *Violet* arrived at Sheerness, on the 10th inst., with a considerable rent in the port side near the fore bridge, the damage having been received in a collision with a sailing vessel in the North Sea. The *Violet* was towed to Sheerness by the *Falcon*, and has since been docked for repairs. It is stated that the fore part of the vessel in front of the bow gun will have to be practically rebuilt. The third mishap was to the *Lee*, which arrived at Devonport on Sunday with a hole in her starboard side, caused by a collision with the Dutch cruiser *Friesland*, off Torbay. Several of the crew who were asleep, had narrow escapes. The *Friesland*, which was practically undamaged, offered assistance after the collision, but it was found not to be required.

The destroyer *Quail* was towed into Portsmouth on the 7th of August, in a sinking condition, having been in collision with the scout *Attentive*, while engaged in night operations with the home fleet off Swanage. The destroyer presented a curious appearance when placed in dock, about 40 feet of her bow up to the conning-tower being shorn clean away, leaving the mess deck exposed. A grave disaster was narrowly averted, and several men had marvelous escapes. On the following day it was announced that the destroyers *Kestrel* and *Teviot*, of the Portsmouth flotilla, were in collision about 1 a. m. off Swanage. The former's bow was badly damaged, but the injury to the *Teviot* was very slight. The cruiser *Eclipse* took the *Kestrel* in tow, and towed her stern foremost to Portsmouth, where she was placed in dock. The *Cynthia*, of the same flotilla, was also towed to Portsmouth, her steering apparatus being disabled. On the *Kestrel* being docked it was found that about 30 feet of her bow had been damaged.—*United Service Gazette.*

LAUNCHES.—The first-class armored cruiser, *Inflexible* was launched June 26, and is the last to be put into the water of the three vessels of similar design ordered by the Admiralty. All three ships are identical in their features, and their auxiliary machinery has been made to be inter-

changeable. The turbines are alike in their general dimensions, so that they may be transferred from one vessel to another. The details of the design have not been officially disclosed. The principal dimensions and features are, however, available. She has a length over all of 530 feet, a beam of 78 feet 6 inches, with a draft of 26 feet. The weight of the hull is given as 9660 tons, and the displacement 17,250 tons. The engines are to develop 41,000 I. H. P. The speed to be attained is 25 knots, the coal capacity at load draft being 1000 tons. The machinery is of the Parsons steam turbine type, steam being supplied from water-tube boilers. There will be four shafts. On each of the two inner shafts there will be a cruising turbine—low pressure ahead and low pressure astern—while on each of the outer shafts will be a high pressure ahead and a high pressure astern turbine. The *Inflexible's* armament will consist of eight 12-inch guns, equal to 381,576 foot-tons for one round. All the guns can be fired on either broadside. The bow guns are on the center line forward, while on the same high level there is amidships, on each broadside, a pair of guns in barbettes, which are not in the same athwartship line. The barbette on the port side is sufficiently further forward than that on the starboard side to enable all four amidship guns to fire on either side. The *Inflexible* has a complete belt of armor from bow to stern, the maximum thickness being 7 inches, tapering to 4 inches at each end. The guns will be within 7-inch barbettes, and have large armor hoods. The cruiser will also have machine guns for defence against torpedo attack.

The *Tartar*, one of the new ocean-going torpedo-boat destroyers ordered from Messrs. John I. Thornycroft & Co. (Limited), was also launched on the 27th. The dimensions of the vessel are: Length, 270 feet; beam, 26 feet; draft, 8 feet 2 inches. The contract speed is 33 knots. The vessel is to be fitted with turbine machinery of the Parson's type (built by Messrs. Thornycroft) and six Thornycroft water-tube boilers, arranged for burning oil fuel. The armament will consist of three 12-pounder quick-firing guns and two 18-inch torpedo-tubes.—*United Service Institution.*

THE NEW TORPEDO-BOATS.—The 12 first-class torpedo-boats provided for in the program for 1906-7, and recently ordered to be built by contract, are to be numbered consecutively from 13 to 24. The boats will be larger and will have greater capacity for the storage of oil fuel than torpedo-boats Nos. 1 to 12, built under the program for 1905-6, whose length varies from 166 feet 6 inches to 180 feet, with displacements varying from 215 to 235 tons. The new boats will vary from 173 feet to 185 feet in length, with displacements from 251 to 280 tons. Their engines will be of 4000 I. H. P. (250 I. H. P. in excess of the power of Nos. 1 to 12), and their storage for oil fuel will range between 23 and 25 tons at load draft. The new boats will steam 26 knots, and will be equipped with two 12-pounder quick-firing guns and three torpedo tubes. The boats will be built by the following firms: Two by Messrs. Denny Brothers, Dumbarton; two by Messrs. Hawthorn, Leslie & Co., Newcastle-on-Tyne; one by Palmer's Shipbuilding Company, Jarrow; two by Messrs. Thornycroft & Co., Woolston; four by Messrs. J. S. White & Co., Cowes; and one by Messrs. Yarrow & Co., Poplar.—*United Service Institution.*

THE NAVAL DEBATE.—The discussion on the shipbuilding vote was particularly interesting. Mr. Robertson confined his remarks to questions concerning the material side of the navy. After explaining the steps which are being taken for the better ventilation of the magazines, he referred to the future program, and its bearing on the maintenance of the two-power standard. It is now acknowledged freely by everyone that we are stronger than the two-power standard, and must be stronger for some time to come. Mr. Robertson tells us that two more *Dreadnoughts* are to be laid down in November on the slips vacated by the *Bellerophon* and *Temeraire*, and that another one will be put out to contract early next year, unless, as is

most improbable, something definite is decided by the Hague Conference concerning disarmament. Turning to the cruiser policy, he explained the principles upon which this is based. There is not one writer or student of naval matters, whose judgment and experience make his opinion valuable, who has not endorsed the policy of the Admiralty in this direction. It is generally acknowledged that of all naval problems that which concerns the cruiser is the most difficult; and it must be remembered that in formulating the two-power standard originally Lord George Hamilton confined himself to battleships, and to battleships only. With the exception of a very small group of critics, who are not agreed amongst themselves, the consensus of naval opinion favors three classes of cruisers. One class fitted to fulfil the primary function of cruisers, that of controlling the lines of communication and acting as the fast wing of the battle fleet—fit to be detached at need as scouts, or or the support of a more numerous but less powerful squadron of smaller vessels. A second class more numerous and faster but less well armed and protected, and with a narrower range of action; the function in this case being police duties in time of peace and commerce defenders in time of war. The third class to perform the duty of despatch vessels and the supports of destroyers. It is the functions that control the type, and the Admiralty believe that in the *Invincible*, a new *Edgar*, and the *Boadicea* classes they have found types suitable for their purpose. If we understand Mr. Robertson aright, we may expect, therefore, shortly that the program of construction will contain a number of these smaller cruisers.

Very directly connected with the cruiser policy is the question of the strength and composition of our torpedo flotillas. It has been well pointed out that the advent of the torpedo flotilla and its power of offence against larger types of ships introduce a new condition both tactically and strategically, and the problem thus presented requires a new solution. The new destroyers, indeed, have two functions to perform—that for which they were originally intended, the destruction of other torpedo craft; and that for which the late war proved them to be most deadly, the attack with torpedoes on larger vessels. Moreover, there is still room for the torpedo-boat, and therefore it seems likely that both ocean-going destroyers and torpedo-boats of the new type must be found in the new programs. As we understand Mr. Robertson, this, with the addition of submarines, is what we may expect.—*Army and Navy Gazette.*

ADMIRALTY SURVEYS.—The report on Admiralty surveys for the year 1906 has been issued in the form of a Blue Book. During the year the rocks and shoals dangerous to navigation which were reported numbered 367; a length of 658 miles of coast line was charted, and an area of 2950 square miles was sounded over by British surveying vessels, but the need for more numerous and more detailed hydrographic surveys is manifest, particularly in those parts where commece is spreading into localities which are but still imperfectly charted. From officers of His Majesty's ships 58 charts, plans, and sketches of anchorages were received for the amendment of official documents; the new charts published amounted to 116, and 66 plates were improved by the addition of 84 new plans; while 86,868 charts have received corrections.—*United Service Gazette.*

Le Yacht gives the following particulars of the *Bellerophon* class: They displace 18,600 tons; have a maximum speed of 21.5 knots, with 24,700 horsepower at four shafts actuated by turbines; and can steam 5800 knots at 12 knots speed on their normal coal supply of 900 tons. At full load they can carry 2500 tons of coal and oil. Their armament consists of ten 12-inch guns of 50 calibers, mark XI, and more powerful than the 45 calibers, mark X, guns of the *Dreadnought*. All the 12-inch guns are in double turrets on the midship's line. The second battery is composed of 4-inch guns, and there are five 18-inch under-water torpedo tubes. The

belt armor is 11 inches at the center and 4 inches at the ends; the turrets and forward conning-tower are 11 inches; the after conning-tower is 8 inches; the principal armored deck is 2.75 inches on the slope and 1.75 inch on the flat. There is also an arrangement, intended for torpedo protection, by means of which the gases of explosion can find free exit between the inner and outer skins. The full complement will be 850 men.

ITALY.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
Roma	12,625	Gov't Yard, Spezia.	Launched Apr. 21, 1907.
Napoli	12,625	" " Naples.	" Sept. 10, 1906.
Vittorio Emanuele	12,625	" " Castellamare.	" October 1, 1904.
Armored Cruisers.			
San Giorgio	9,800	Gov't Yard, Castellamare.	Building.
San Marco	9,800	" "	"
Pisa	9,800	Orlando.	"
Amalfi	9,800	Odero.	"

Following are trial results of the *Regina Elena* in her 24 hours' trials at four-fifths power—15,200 horsepower—I. H. P. 15,473 = 20.33. The *Vittor Emanuele* in her preliminary runs at four-fifths for eight hours made 16,000 I. H. P. and 21 knots.—*Engineer.*

The Superior Council has prepared a new naval program, the cost of which will reach nearly 160 million francs. This program will include 16,000-ton battleships, very heavily armed, but with a small coal supply; torpedo-boats of at least 500 tons; and submarines of 150 tons. The first of the new battleships is to be laid down at Castellamare after the launching of the *San Giorgio.*

The *San Marco* is to be launched in the spring of 1908, and it is hoped to finish the *San Giorgio* by July, 1909. The similar ships, *Pisa* and *Amalfi*, are to be delivered in April and June, 1908.—*Le Yacht.*

The Italian naval authorities have decided to sell or break up a number of battleships and other vessels during the five years 1907-12. The list comprises 21 ships of various classes, including the *Duilio* (launched in 1877) and the *Andrea Doria* (launched in 1891), as well as numerous torpedo-boats. With the proceeds, which are estimated at £260,000, the government intends to make large purchases of coal for the Italian Navy.

The armor-plate factory at Terni has accepted a contract to provide the Italian Navy with 6000 tons of armor-plate at the same price as that at which the Midvale Steel Company, of Philadelphia, recently took a contract from the Italian government. Thus the contract with the American company has had the effect of forcing the Italian works to lower their prices, and the result is a saving of £16,000 to the Italian government. *Page's Weekly.*

JAPAN.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
Satsuma	19,200	Yokosuka.	Launched Nov. 15, 1906.
Aki	19,800	Kure.	" Apr. 15, 1907.
Armored Cruisers.			
Ibuki	13,750	Yokosuka.	Building.
Kurama	13,750	"	"
Haki		Kure.	"
Protected Cruiser.			
Tone	4,100	Sassebo.	Building.
Scouts.			
Yodo	1,350	Kobe.	Building.
Mogami	1,350	"	"

Le Yacht states that a photograph taken of the *Aki* when being launched shows only two lines of shafting, clearly indicating that she is to have reciprocating engines and not turbines. The Curtis turbines being built by the Fore River Co. for Japan must be for some other ship.

JAPAN'S NAVAL PROGRAM.—The Tokio correspondent of *The New York Herald* sends some interesting particulars of Japan's work in creating a modern navy. Among other things the writer says: "At Kure Japan has as fine a navy yard as the world knows. Here there is to be found everything in the way of the most modern machinery. More than 30,000 men are continually employed, work being carried forward by night as well as by day. The Japanese naval authorities point with pride to the fact that the *Aki* was turned out from the date of laying down to the date of launching, in eight months of actual working time. They have good reasons to feel proud of the feat."

Some facts regarding the program of naval expansion are then given, and the correspondent then continues:

"In their estimates of naval strength the Japanese experts eliminate vessels 10 years old and over, since in view of the great progress made in naval architecture and construction such ships cannot be counted on as able to take their place in battle against the newest and most modern ships.

"This leaves Japan's present naval strength in large warships—new vessels and those under 10 years of age—as follows:

Battleships.

Name.	Approximate Tonnage.	Age.
Shikishima	15,000	9
Asahi	15,000	8
Mikasa	15,000	7
Iwani (Orel)	13,500	5
Hizen (Retvizan)	13,000	6
Seiwo (Pobieda)	13,000	8
Katori	16,000	3
Kashima	16,000	3
Satsuma	19,200	1
Aki (just launched)	19,800	—

First-class Cruisers.

Asama	9,800	9
Tokiwa	9,800	9
Yakumo	9,800	8
Azuma	9,500	8
Iwate	9,900	7
Izume	9,900	8
Kasuga	7,700	4
Nisshin	7,700	4
Aso (Bayan)	7,700	8
Tsukuba	13,700	3
Ikoma	13,700	2

Second and Third-class Cruisers.

Kasagi	5,000	9
Chitose	4,800	9
Tsugaru (Pallada)	6,700	8
Soya (Variag)	6,500	8
Niitaka	3,500	5
Tsushima	3,500	5
Otowa	3,000	4

Twenty-eight battleships and cruisers with total displacement of (about) 300,000 tons.

"Of course the substitution of live ships for the dead ones on the obsolete list makes necessary much of the activity now so manifest in the shipyards at Kure and Yokosuka. Then, too, a great deal of work has been done, and is being done, on the vessels captured from Russia. Some of these have had to be almost entirely rebuilt. How many of them will, even after this rebuilding process, be worth classing as strictly first class it is impossible to say, but it is apparent from the comment heard in navy circles that the Japanese authorities do not set any great store by them.

"Their chief reliance for their navy of the future is in new ships, and they are going to have just as many of these as the willing, if overburdened, taxpayers of a nation fired with intensest patriotism will stand."—*Nautical Gazette.*

The Japanese budget includes 5,770,000 francs for repairing the *Mikasa.* It is said that her eight 6-inch guns will be replaced by four 10-inch placed at the corners of the superstructure.

RUSSIA.

VESSELS BUILDING.

Name.	Displacement.	Where Building.	Remarks.
Battleships.			
Emperor Paul I	16,900	St. Petersburg (Baltic Yard).	Launched Sept. 7, 1907.
Andrei Pervozvannui	16,900	St. Petersburg (Galerney Island).	Launched Oct. 20, 1905.
Evstafi	12,500	Nicolaiev.	" Oct. 1906.
Ivan Zlatoust	12,500	Sevastopol.	" May 13, 1906.
Armored Cruisers.			
Admiral Makaroff	7,800	La Seyne.	Launched May 8, 1906.
Bayan	7,800	St. Petersburg.	" Aug. 15, 1907.
Pallada	7,800	"	" Nov. 10, 1906.
Rurik	15,000	Vickers.	Under trial.
Protected Cruiser.			
Outchakoff	6,750	Sevastopol.	Building.

The name of the cruiser *Kagoul* has been charged to *Pamiati-Merkouria.* The *Rurik* is now finishing her trials; she easily maintains a speed of 21.5 knots.—*Le Yacht.*

UNITED STATES.

VESSELS BUILDING.

No.	Name.	Speed. Knots.	Where Building.	% of Completion Sept. 1, 1907.
	Battleships.			
23	Mississippi	17	Wm. Cramp & Sons.	92.0
24	Idaho	17	Wm. Cramp & Sons.	86.0
25	New Hampshire	18	New York Shipbl'g Co.	83.0
26	South Carolina	18.5	Wm. Cramp & Sons.	21.7
27	Michigan	18.5	New York Shipbl'g Co.	24.0
28	Delaware	21	Newport News.	0.0
29	North Dakota	21	Fore River.	0.0
	Armored Cruisers.			
9	South Dakota	22	Union Iron Works.	98.9
12	North Carolina	22	Newport News.	89.0
13	Montana	22	Newport News.	82.6
	Scout Cruisers.			
	Chester		Bath Iron Works.	88.7
	Birmingham		Fore River Shipb'g Co.	87.8
	Salem		Fore River Shipb'g Co.	86.6

CONTRACTS FOR BATTLESHIPS AND ARMOR AWARDED.—The Secretary of the Navy has awarded the contracts for the two battleships of the so-called *Dreadnought* class to the Newport News Shipbuilding & Dry Dock Co. and the Fore River Shipbuilding Co., respectively. The proposals of the former company would have enabled the government to build both vessels at much lower cost than will now be possible, but the law forbade the allotment of more than one ship to a single contractor.

In accepting the bid of the Newport News Shipbuilding & Dry Dock Co. the department gives the contractor the alternative of building a vessel on the company's plans, involving the use of the Parsons turbine for motive power, with certain slight modifications suggested by the experts of the Bureau of Construction and Steam Engineering, or upon the original plans of the department, which include reciprocating engines. If the former proposition is accepted the contractors will receive $4,090,000; otherwise they will be paid $3,987,000.

Two Turbine Battleships Probable.—The bid of the Fore River Shipbuilding Co. accepted by the department is based on the use of the Curtis type of turbine, the contract price being $4,377,000. It will thus be seen that if the Newport News Shipbuilding & Dry Dock Co. elects to build on its own plans, which is regarded as highly probable, both big battleships will be equipped with turbine engines, which will mark a most important innovation in the American Navy, no other ships of this type having been designed for turbine motors.

The Secretary of the Navy has had little difficulty in disposing of the bids submitted by the naval constructors of the Brooklyn and Mare Island Navy Yards for the construction of the two big vessels. The lowest of these bids, it is now learned, was approximately $700,000 higher than the minimum bid of the Newport News Shipbuilding & Dry Dock Co. and more than $300,000 higher than the bid of the Fore River Shipbuilding Co., upon which the contract to that company has been awarded.

Armor Contracts.—After an important readjustment of the bid of the Midvale Steel Co., the contracts for the armor for the two battleships have been awarded as follows: Bethlehem Steel Co., 3602 tons; Carnegie Steel Co., 3543 tons; Midvale Steel Co., 2230 tons. These awards are made on the basis of $420 per ton for Class A armor (7956 tons) and $400 per ton for Class B (952 tons), Class C (392 tons), and Class D (76 tons). In submitting its bid the Midvale Steel Co. reclassified the armor according to the mechanical difficulties to be encountered in its manufacture and quoted prices on the basis of a series of five groups. The Secretary of the Navy did not regard this as a satisfactory basis for comparisons and he therefore advised the Midvale Co. that its bid could not be considered unless submitted in accordance with the department's schedule. The proposal based on groups was then withdrawn and the Midvale Company offered to make armor at the same prices as those quoted by its competitors, whereupon a contract was awarded as above indicated.—*Iron Age.*

TURBINE SCOUT CRUISER LAUNCHED.—The new scout cruiser *Chester* has been launched successfully from the yard of the Bath Iron Works.

The *Chester* is one of three vessels of this type authorized by the act of Congress of April 17, 1904, and was awarded to the Bath Iron Works at a contract price of $1,688,000, with contract time of delivery set at May 4, 1908. Her sister ships are the *Salem* and the *Birmingham*, both building at Quincy, Mass.

The dimensions of the *Chester* are as follows: Length over all, 423 feet 2 inches; breadth, 46 feet 8 inches; draft, fully loaded, 19 feet 1½ inches; depth amidships, molded, 36 feet 8 inches; displacement, fully loaded, 4840 tons; displacement on trial, 3750 tons; trial draft, 16 feet 9½ inches.

Two 5-inch guns and six 3-inch guns, also two 21-inch submerged torpedo tubes; will make up her battery. The machinery consists of six turbines, driving four independent shafts, each fitted with one propeller. These turbines are installed in two separate water-tight compartments,

and so arranged that should one compartment become injured or flooded the ship could still be maneuvered. Steam is to be furnished by 12 water-tube boilers. Her contract speed is 24 knots.—*Nautical Gazette.*

OIL AS FUEL FOR WARSHIPS.—The Bureau of Equipment, Navy Department, has decided, in order to determine the relative efficiency of oil and coal as fuel for warships, to equip the monitor *Wyoming* with apparatus which will permit the burning of oil. For some time the department has had in mind thorough experiments with oil as fuel, and preliminary investigations along this line have given the officials reason to believe that a thorough test will prove oil a far more satisfactory fuel, from many points of view, than coal. At any rate, they believe it will show an improvement over the soft coal that is generally used on warships. After making preliminary cruises out from Mare Island, the Wyoming will set out for a long-distance test, Hawaii being the objective point. The oil-burning apparatus will be arranged so that it may be removed and coal used in the regular way, in order that a direct comparison of the two fuels may be made on the same ship under the same weather conditions.—*Nautical Gazette.*

NEW TRAINING SHIP IN COMMISSION.—The U. S. S. *Cumberland* has just been placed in commission at the U. S. Naval Training Station, Newport, R. I. The new steel vessel is a sailing ship carrying six 4-inch rapid fire guns in her main battery and is named after the famous old Cumberland that was sunk by the Merrimac in the Elizabeth River in 1862, with her colors flying. The new Cumberland is to be used for the training of apprentice seamen.—*Nautical Gazette.*

THE OCEAN RACE OF TORPEDO-BOAT DESTROYERS.—Although the recent ocean race of six of our largest torpedo-boat destroyers, over a 240-mile course from Sandy Hook to Cape Charles, has not turned out to be as great a fiasco as similar races of this kind that have been held in by-gone years in other navies, it can hardly be called a success. The first race of this character, if we remember rightly, took place some 20 years ago, when a large number of torpedo-boats were sent at full speed over a course laid up the English Channel; and it served mainly to demonstrate the frailty of these craft and the impossibility of relying upon them for any long-continued speed effort over a lengthy course. Such of the boats as were not crippled in the engine room or boiler room, began to show evidence of structural weakness. The race left no doubt that the torpedo-boats of that day were altogether too light for deep-sea duty; and it was partly as the result of this experience that the dimensions and scantling of torpedo craft were increased , and the torpedo-boat developed into the dignity of the torpedo-boat destroyer. The increase in size since that date has been steady, the displacement having gone up from 80 or 100 tons to from 300 to 400 tons, while the latest British destroyers are of 500 tons displacement. But even the modern destroyer appears to be unable to maintain full speed for more than a few hours at a stretch. Probably the best work that has been done of late years was the deep-sea service of the Japanese destroyers during the operations at Port Arthur, when these vessels kept the sea, except for occasional visits to a naval rendezvous, through all the stormy months of the winter blockade. It is certain, however, that most of this service was performed at a moderate cruising speed.

TORPEDO BOAT DESTROYERS IN THE SANDY HOOK-CAPE CHARLES RACE.

	Length.	Beam.	Draft.	Displacement on Trial, Tons.	Maximum Coal Supply, Tons.	Horse-power.	Trial Speed.
Whipple....	248′ 0″	22′ 3½″	6′ 0″	481*	177	8,300	28.24
Truxtun....	248′ 0″	22′ 3½″	6′ 0″	481	177	8,300	29.58
Worden	248′ 0″	22′ 3½″	6′ 0″	476	177	8,300	29.86
Hull	238′ 9″	23′ 1½″	6′ 0″	449	165	9,119	28.04
Hopkins....	238′ 9″	23′ 1½″	6′ 0″	467	165	8,456	29.02
Stewart	245′ 0″	23′ 1″	6′ 6″	429	184	8,000	29.69

* Because of the large amount of stores, ammunition, coal, water, furniture on board, these vessels at the commencement of the race displaced nearly 700 tons.

The division of torpedo-boats engaged in this race contained representatives of the best of our destroyers. The latest and probably the most efficient of the six is the *Stewart*, whose dimensions may be taken as representative of the 16 vessels which compose our destroyer fleet. She is 245 feet long; 23 feet 1 inch in beam, and draws 6 feet 6 inches at normal draft. Her displacement on trial was 439 tons, and her trial speed 29.69 knots an hour. The great disparity between the trial speeds of these boats and the speeds which they are able to develop on a sudden order for a run under full power, is to be attributed: First, to the rapid all-round depreciation due to the light construction both of hulls and engines. Secondly, to the fact that, as in the present case, the hulls are frequently foul because of the lengthy absence from drydock; and thirdly, to the fact that in the cruising condition they are so weighted down with ammunition, general stores, coal, water, and the furniture necessary for living accommodation, that they not infrequently displace fully 50 per cent more than they did on trial. Thus the *Hull*, when on trial, stripped for speed, and with just enough water and coal for the occasion, displaced about 450 tons. On crossing the line at Sandy Hook, she displaced about 680 tons.

The boats started abreast across an imaginary line drawn from the Sandy Hook lightship at 8.33 on the morning of June 6. Each vessel, judging from the blowing off of the safety valves, was carrying a full head of steam, and they were speedily hull down to the observers at the Sandy Hook station. Although the boats were credited with trial speeds of from 28 to nearly 30 knots an hour, it was not anticipated that they would average more than 22 or 23 knots an hour over the whole course. This should have brought them into Hampton Roads at about 6 o'clock the same evening.

The winner of the race was the *Worden*, whose time, taken by the American fleet as she passed the Cape Charles light, was 7.40 p. m., the elapsed time for the run being 11 hours and 7 minutes. This works out at just 21.6 knots average for the whole distance—a rather poor showing for the crack boat of half a dozen supposed 28- to 30-knot craft. The *Worden* was being closely pressed by the *Hopkins*, when suddenly off Hog Island, the latter broke a propeller strut, and was completely disabled. The propeller, thrashing wildly around, tore a hole in the after compartment, and the *Hopkins* had to signal for assistance. Her after bulkhead held, fortunately, as did her pumps, and with the aid of a line from the *Whipple*, she was able to reach Hampton Roads at 8 o'clock on the morning of June 7. It is only fair to state that the *Hopkins* and *Whipple* had averaged a higher speed than 21.6 up to the time of the accident, the *Whipple* slowing down subsequently.

The other boats made a pitiful showing, the *Hull* taking 16 hours, the *Stewart* 21 hours, and the *Truxtun* 22 hours to cover the 240 knots.—*Scientific American.*

PRESENT AND PROSPECTIVE DOCKING FACILITIES OF THE PACIFIC COAST.—Now that the main strength of the United States Navy may be transferred, temporarily at least, to the Pacific, it becomes interesting to know what the docking facilities are on that coast. Outside of possible accidents, the cruisers and battleships will have to be docked at stated intervals in order to have their hulls cleaned and repainted. As a matter of strict economy, it is said that a steel bottom ought to be cleaned and repainted at least once a year. Now on the entire Pacific coast the United States government has just two dry docks—one at Mare Island in San Francisco bay, and another at Bremerton, Wash., on Puget Sound. Both of these are graving docks. The drydock at Mare Island is of granite, 513 feet long over all, with a width of 80 feet 7 inches at the entrance, and a depth of 27 feet 6 inches over sill. The drydock at Bremerton has a wood body and masonry entrance. Its length over all is 650 feet, width of entrance 92 feet 8 inches, and depth over sill 30 feet.

The inevitable naval base under the new order will, of course, be at San Francisco; and the docking facilities of that port consequently become a subject of more than ordinary importance. As may be readily seen, the drydock at Mare Island will be inadequate to the needs of the occasion. To be sure, a second graving drydock at Mare Island has been under process of construction for the past six years; but from various causes much delay has been occasioned, and it is stated upon good authority that it would take two or three years to finish the work, even though it were to be hastened with all possible speed. This new dock when finished will be 720 feet long, 102 feet wide, and 30 feet deep. The chief difficulty thus far encountered is in securing a substantial foundation. The formation composing its site is hardly more than a deep bed of mud; and in order to secure a foundation that will hold up the structure when finished, it is found necessary to drive a dense mass of wooden piling. Upon this foundation it is proposed to build the dock of reinforced concrete.

Fortunately, however, the government need not depend upon itself for docking facilities in San Francisco bay. At Hunter's Point on the west shore of the bay, five miles south of the city of San Francisco, the San Francisco Dry Dock Company operates a very extensive plant, and has already done considerable docking for the government, notably that of the *Oregon* in 1894 and of the *New York* in 1903. Recently the chief engineer of the company has completed plans for the largest drydock in the world, to be soon constructed by the company at Hunter's Point. The company's present plant consists of two graving docks and two floating docks. The first graving dock was completed in 1868. It is 490 feet long over all, 97 feet wide at the gate top and 56 feet wide at the gate sill; midships it is 117 feet wide at the top and 58 feet wide at the bottom. This dock has wooden altars and wooden caisson. The second graving dock was completed in 1903, and in it the *Ohio* was docked in February of that year. This dock is 750 feet long over all; width at gate top, 103½ feet; at gate bottom, 86 feet; midships at top, 122 feet wide and 74 feet at bottom. This dock has concrete altars and a steel caisson; it is filled through the caisson, while the old dock is filled through a seven-foot tunnel.

The largest drydock in the world to-day is at Belfast, Ireland; San Francisco will shortly possess a dock of even greater dimensions. The new drydock above referred to will be 1050 feet long from gate to the landward extremity; width at coping, 144 feet, and at bottom, 92 feet; depth over sill and below coping, 39 feet 10 inches, or 34 feet 6 inches at high water. The interior facing of the dock will be of reinforced concrete of an average thickness of 15 inches; and the altars will be of the same material. The stairways and timber slides will be formed in the main body of the dock, and will be flush with the surface of the same. Such portions of the sides of the dock as will be above the rock formation underlying the site will be reinforced concrete, and will be proportional in thickness to the height of the same, and anchored into the rock with structural steel posts. The gate seat proper will be of dimension granite, but the approach and buttresses will be of reinforced concrete. The keelsons are to be of Douglas fir and the flooring of Port Orford cedar, all anchored and embedded in a sub-floor of cement. The drainage of the dock will be by surface gutters connected with a sump. The caisson or gate will be of steel construction, and will be virtually a vessel 147 feet long at the deck, 128 feet long on the keel, with a beam of 26 feet and a depth from deck to bottom of 41 feet.

The pumping plant for the new dock will consist of four 54-inch centrifugal double suction pumps with a joint capacity of 200,000 gallons of water per minute. Each pump will be driven by a 500-horsepower three-phase electric motor, using 440 volts. These will be located at the bottom of the pump pit, and will be so arranged as to be started from the gallery at floor level, it being the intention to use the high-tension current of one of the public service power companies, say at 1000 volts, and transform the same to the requisite voltage.

The dock will hold 24,000,000 gallons of water, but with the pumping plant described, may be pumped out within the space of two hours. The earth conditions at Hunter's Point are very favorable for the construction of graving drydocks, the site of the present docks and of the proposed dock being underlaid with what is known as green serpentine rock, forming a very solid foundation, as well as substantial backing for the sides.

The new dock was neither conceived nor planned in anticipation of any possible massing of the United States navy, but in anticipation of the constantly increasing size of ocean craft and the growing importance of the Pacific Ocean as a maritime field of operation.—*Scientific American.*

ORDNANCE AND GUNNERY, TORPEDOES.

An official return, prepared by Rear-Admiral Sir Percy Scott, late director of target practice, giving the results of the gunlayers' tests of the fleets, has been issued fom the Admiralty. The positions in order of merit of the several squadrons and ships were as follows:

1. China squadron, 52.23 points. Best ship: *King Alfred*, 76.11 points.
2. Mediterranean fleet, 46.80. Best ship: *Prince of Wales*, 62.98.
3. Atlantic fleet, 45.34. Best ship: *Albion*, 62.35.
4. Home fleet, 37.72. Best ship: *Victorious*, 53.46.
5. Fifth cruiser squadron, 35.88. Best ship: *Duke of Edinburgh*, 47.95.
6. Australian squadron, 35.66. Best ship, *Powerful*, 50.
7. Channel fleet, 34.45. Best ship: *Ocean*, 42.25.
8. Third cruiser squadron, 33.41. Best ship: *Bacchante*, 42.45.

Amongst other statistics there is a diagram giving the percentage of hits to rounds fired in the gunlayers' tests of the fleets during the past 10 years. In 1897 the percentage of hits was 31.86, and in 1899, which was the lowest of the 10 years, it was 31.1. By 1903 the figures had risen gradually to 46.04, but in the next year they went back to 42.86. From then there was a rapid improvement. In 1905 the percentage of hits was 56.58, and in 1906 it advanced to 71.12, while this year the total percentage for the whole of the fleets reached 81.49 hits out of every hundred rounds fired. About 20 more ships have yet to fire to make this year's practice complete.

The cruiser *King Alfred*, flagship of Vice-Admiral Sir A. W. Moore, commander-in-chief on the China station, has attained most extraordinary results during gunnery practice at Wei-hai-Wei. In all 198 rounds were fired from 18 guns, and 188 hits were made, of which 112 were bulls. The results with three 6-inch guns in one minute were: 11 rounds, 11 hits, 11 bulls; 14 rounds, 13 hits, 8 bulls; 13 rounds, 13 hits, 9 bulls. With her two 9.2-inch guns the results were in two minutes: 10 rounds, 10 hits, 8 bulls; 9 rounds, 9 hits, 7 bulls. This practice surpasses even the firing in the similar gunlayers' test last year by the sister-ship *Drake*, then flagship of Rear-Admiral Prince Louis of Battenberg. 167 rounds were then fired from a similar number of guns, and 146 hits were recorded. The *King Alfred* is thus 42 hits to the good, and is far ahead of every ship in the British fleet.

A record for the 6-inch guns in the Atlantic fleet this year has just been made by the battleship *Albion*, in the gunlayers' test at Tetuan, the vessel having remained behind at Gibraltar for repairs when the fleet came to England to give leave to the crews. Ninety-one rounds were fired, resulting in 89 hits, of which 64 were "bulls." Only the latter count in this year's gunlayers' test, although hits are recorded for the purpose of comparison with the previous year's firing. The best individual score in the *Albion* was nine rounds and nine bulls, the next best being eight rounds, seven bulls, and an outer.—*United Service Gazette.*

THE 1907 GUNLAYERS' TEST.—The 1907 gunlayers' test is now nearly over in all the heavy first-line fleets, such as the Channel, Atlantic, and Mediterranean, but the home fleet divisions, and some of the large and

small cruiser squadrons at home and abroad, have yet to complete. Enough has been done, however, to show that there is once again a most gratifying advance in the all-round shooting of the ships, and no part of the progress is more satisfactory than that which is so strongly marked in the scores of our largest present-day naval weapons, viz., the huge 12-inch pieces. For obvious reasons this has pleased the experts immensely, especially those who prophesy that future naval battles will chiefly be decided by guns of the largest caliber, and that an action will be practically settled before any secondary armament can be brought into play.

In a recent issue we criticised, somewhat severely, the way in which night firing had been neglected in the navy, and we do not withdraw a single stricture from what we then uttered. But we are the first to admit that in day firing rapid and accurate firing is making satisfactory progress, and emphatically disagree with those who are assiduously circulating the report that the gunnery spirit in the navy has lost its edge, and that shooting competitions are falling flat through being overdone. There is no shadow of evidence of any such thing in this year's gunlayers' test, while if such a falling-off of keenness was to be found at all, it would instantly be reflected in this competition, which concerns only the men.

Instead of there being a decline, there is an all-round advance, as evidence of which we have but to take only one fleet as an example. In 1906, in the time allowed, the 12-inch guns fired 60 rounds and made 33 hits. In 1907 the 12-inch weapons, mounted in the same fleet, fired 70 rounds and made 33 hits, and out of these 22 were bulls'-eyes. Although the number of hits were the same in 1907 as in 1906, yet this year 10 more rounds were fired in the time. This is a gain, for although the extra 10 shots did not find the target, yet if the object had been a battleship most of them would have struck and probably destroyed some upper-works, such as the funnel, the loss of which at once reduces a ship's speed by two or three knots per hour. Then in the case of the 6-inch guns, last year the Atlantic fleet fired 437 rounds and made 327 hits. This year there were 477 rounds fired, out of which 412 were hits and 343 were bulls'-eyes. This was a remarkable advance, although it must be remembered that there are a few more guns of 6-inch caliber in this year's than in last's Atlantic fleet. Still the percentage of hits is higher, and that is the crucial test.

The size of the target this year is smaller by three feet than it was last year, and only "bulls" count, and this fact makes the shooting even more satisfactory. The rate of loading and rapid firing shows a distinct step forward, and, moreover, gives the lie to those who declare that gunnery keenness in the navy is wearing down. What we want to see is this same spirit of emulation carried into night firing, and the results rise at the same ratio of excellence as that of the day firing. The whole of the Channel fleet result is not to hand as we write, but the Channel fleet has a keen gunnery admiral as its commander-in-chief, and no anxiety need be felt as to its final gunnery efficiency; while the China squadron has done better than for years past, especially with its light (or anti-torpedo) gun, which, as we have before pointed out, is a most important weapon. At one gun Petty Officer Nash made 14 hits with 14 rounds in one minute from a 12-pounder gun. This is a world's record. Altogether, therefore, the officers and men of the navy are to be congratulated on their competitive heavy-gun firing, so far as it has at present gone. But the important test of battle practice has yet to come.—*United Service Gazette.*

In delivering the second of his two lectures upon "The Contest between Guns and Armor," at the Royal Institution, Sir William H. White, the late director of naval construction, traced the influence during the past half century of new theories and experience with guns and armor upon the design of battleships. The adoption of the central citadel system in naval construction, and its eventual supersession having been explained, Sir William remarked upon the changes in construction which had fol-

lowed the use of high explosives and of quick-firing guns of larger caliber. In battle practice the 6-inch quick-firing gun had proved its superiority over the 12-inch gun in accuracy measured by percentage of hits. Recent naval experience had again proved that a ship might be demoralized, captured, or even sunk without her heavy armor being perforated. The perforative power of the 6-inch gun was, of course, lower than that of the larger weapon; but there were other matters to be considered, and there were many, among whom the lecturer declared himself one, who held that it was not desirable to depend exclusively upon guns of large caliber. The French naval authorities had decided in favor of this view, and the Russo-Japanese War had shown the immense damage that smaller guns could do.—*United Service Gazette.*

As a result of the inquiry into the recent disaster on the French warship *Iéna*, an Admiralty order has been received at Pembroke dockyard directing the installation of a new system of ventilation in the magazines of all British warships, whether in commission or building. The new system provides for the keeping of the temperature of the magazines at all times below 70 degrees F., and the order directs that estimates are to be prepared for fitting the installation into all ships at Royal dockyards. Authority is given to employ additional hands if necessary for the purpose of carrying out the work. The alterations are to be regarded as urgent.—*United Service Gazette.*

CORDITE.—In the discussion that took place in the House of Commons on cordite, the question of its safety was very seriously debated. The powder adopted by our government consists of a mixture of gun-cotton and nitro-glycerine, in the proportions of 65 per cent of the former to 30 per cent of the latter, together with a little vaseline, and should contain no other ingredient whatever, with the exception of a trace of acetone, the solvent used in dissolving the nitro-cotton, due to insufficient drying. There is no chemical reason to add such a substance as chloride of mercury. Its addition can only, according to government views, be for the purpose of masking the heat test, and the proceeding is a "violation of the contract," as pointed out by Mr. E. Robertson. The addition of mercuric chloride to cordite would not of itself render the powder more dangerous, but the presumption is that it is only added to cordite that is in itself in a dangerous condition, *i. e.*, the ingredients from which it has been manufactured, more especially the nitro-glycerine, and probably also the nitro-cellulose, have not been sufficiently purified. It is a well-known fact that in washing these substances very great care is necessary, and the process is a long and tedious one. Both the nitro-glycerine and the gun-cotton must stand a satisfactory "heat test" before they are mixed, and even when these tests are satisfactory it occasionally happens that the finished explosive will give a bad heat test.

The addition of mercuric chloride is not new. We remember hearing of its use some 18 years ago in connection with blasting gelatine. The government heat test was introduced by the late Sir F. Abel, and was originally used for testing the stability of the various forms of nitro-cellulose, especially gun-cotton. Briefly, the process is as follows: A known weight of the explosive is placed in a stout test tube 5¼ inches to 5½ inches long, and of such a diameter that it will hold 20 to 22 cubic centimeters of water. It is fitted with an india-rubber stopper through which passes a narrow glass rod, terminating in a platinum wire hook, to hold the test paper. The test papers are narrow strips of special filter paper that have been treated with a solution of starch and potassium iodide. One of the pieces of filter paper thus prepared—10 mm. by 20 mm.—is fixed upon the platinum wire hook, the top of the paper is moistened with a weak solution of glycerine in water in such a way that the upper half is moist, and there is a distinct boundary line. The rod with the paper fixed upon the platinum hook is now placed in the mouth of

the test tube, and the tube is then placed in a copper water bath, and the temperature raised until the thermometer fixed in the bath registers a temperature of 180 degrees F. Cordite under these circumstances must stand the test for at least 15 minutes. The test is finished when a faint brown line makes its appearance at the boundary line of the portion of the paper that has been moistened by the glycerine and water. The time and temperature varies with different explosives, such as gelatine dynamite, gun-cotton, Schultze powder, etc. The action of the chloride of mercury is to retard the reaction and to cause a sample of smokeless powder that, by reason of inefficient washing, will only give a heat test of perhaps 8 minutes to 10 minutes to stand for a much longer period of time than 15 minutes. The object of the test is therefore defeated, and the powder is made to appear very much superior as regards stability than it really is.

Cordite is chiefly manufactured at the Royal Gunpowder Factory at Waltham Abbey, but also at several private factories. As first manufactured, it consisted of gun-cotton 37 per cent, nitro-glycerine 58 per cent, and vaseline 5 per cent; but the modified cordite now made consists of 65 per cent gun-cotton, 30 per cent of nitro-glycerine, and 5 per cent of vaseline. As gun-cotton is not soluble in nitro-glycerine, it is necessary to use some solvent, such as acetone, in order to form the jelly with nitro-glycerine. The dry gun-cotton and nitro-glycerine is placed in an incorporating tank, some of the acetone added, and after mixing, the rest of the acetone is added—20 per cent in all—and the paste kneaded for three and a half hours. At the end of this time the vaseline is added, and the kneading continued for a further three and a half hours. When the various ingredients are formed into a homogeneous mass, the mixture is taken to the press-house, where, in the form of a plastic mass, it is placed in cylindrical molds; the mold is inserted in a specially designed press, and the cordite paste forced through a die with one or more holes. The paste is pressed out by hydraulic pressure, and the long cord is wound on a metal drum, or cut into lengths; in either case the cordite is now sent to the drying houses, and dried at a temperature of about 100 degrees F. from three to fourteen days, the time varying with the size. This operation drives off the acetone and any moisture the cordite may still contain, and its diameter decreases somewhat.

In the case of the fine cordite such as rifle cordite, the next operation is blending. This process consists in mounting 10 of the metal drums on a reeling machine similar to those used for yarns, and winding the 10 cords on to one drum. This operation is known as "ten-stranding." Furthermore, six "ten-stranded" reels are afterwards wound on one, and the sixty-stranded reel is then ready to be sent away. This is done in order to obtain a uniform blending of the material. With cordite of a larger diameter, the cord is cut into lengths of 12 inches.

Every lot of cordite from each manufacture has a consecutive number, numbers representing the size, and one or more initial letters to identify the manufacture. These regulations do not apply to the Royal Gunpowder Factory, Waltham Abbey. The finished cordite resembles a cord of gutta-percha, and its color varies from light to dark brown. It should not look black or shrivelled, and should always possess sufficient elasticity to return to its original form after slight bending.

With regard to the stability of well-made cordite there can be no doubt: climatic trials have been carried out all over the world, and they have so far proved eminently satisfactory. The Arctic cold of the winter in Canada with the temperature below zero, and the tropical sun of India, have as yet failed to shake the stability of the composition, or abnormally injure its shooting qualities. Stability tests should be carried out more frequently in a hot than in a temperate climate. A powder stored at 104 degrees F. should be tested ten times as frequently as one stored at 68 degrees F. to ensure an equal degree of safety. It is, however, absolutely essential that the powder should stand the heat test in a satisfactory manner. At Waltham Abbey, and at some of the private factories, the nitro-

cellulose used in its manufacture is subjected to Wills' test, which is certainly more severe than the Abel test. In this test the nitro-cellulose is heated to a temperature of 135 degrees C., until decomposition takes place, the products of decomposition being removed and measured. The regularity with which the nitro-cellulose decomposes is a measure of its stability. With regard to nitro-glycerine, it is solely a question of efficient washing; this, however, is often a matter of some difficulty, and occasionally a charge of nitro-glycerine will give a great deal of trouble, and it is often necessary for the charge to be rewashed many times before it will pass the prescribed heat test. The cause of this difficulty is not always easy to discover; it may be due to the fact that the acids used in the nitrating were not clean, or they contained objectionable impurities, or frequently the quality of the glycerine used may be at fault. Whatever the reason may be, it is a fact that it sometimes occurs, and there is no doubt that the addition of substances such as chloride of mercury have been used, with a view of masking the results. It has lately been pointed out that mercuric chloride combines with many nitro-compounds to form salts of an unstable nature; but the use of this salt in masking the Abel—potassium iodide and starch—test has been known for a great many years. In the future it will be necessary in carrying out the heat test on cordite, or any of the nitro-glycerine or nitro-cellulose explosives, to bear in mind the possibility of the presence of this substance. With regard to the question raised as to the mercury salt being added as an antiseptic, we never heard of the necessity for such a thing.—*Engineer.*

THE NEW POINTED BULLET.—The real interest of the Bisley meeting is connected with the performances of the pointed bullet, of which types are being introduced in Germany and France. It is well known that the War Office has been experimenting with a pointed bullet intended to replace the present blunt-nosed projectile. Two types have been presented respectively by Messrs. Kynoch and the King's Norton Metal Company. The present Service bullet is the result of experiments made many years ago, when it was accepted as a fact that the blunt head gave the best results as regards accuracy and resistance to the effects of the air. But a few months ago rumors became rife that bullets with a very pointed nose were beginning to be considered an improvement, and that trials were in hand by the War Office. The great difficulty is that a cartridge to be adopted in the immediate future must conform to the size and shape of the present cartridge in chamber space and length of projectile. If a new rifle were to be introduced, probably a larger chamber would be allowed for the cartridge, and possibly also a breech action capable of standing a greater pressure. There is also the consideration of the penetration and stopping power of the bullet. The War Office, in order to obtain the greatly increased muzzle velocity required, with the object of securing a flat trajectory, has had to take into consideration an increase of the powder charge. Ammunition manufacturers are experimenting, and have found the greatest difficulty in keeping within the necessary limits involved by the fact that ammunition has to stand great differences of climate. These difficulies do not appear to have been altogether overcome, but ultimately a cartridge may be introduced of the same length as the Service one, with a pointed bullet and a muzzle velocity of 2800 feet to 3000 feet per second, as opposed to the 2000 feet per second of the present form.

It was fully believed that the performance of the new bullet would open the eyes of the army as to its possibilities. On the first day of the meeting of the English Eight at Bisley a very strong wind was blowing, necessitating an allowance of some 30 points, but it was reported after the competition that the winner, Cap. J. H. Hardcastle, late R. A., had fired with a cartridge requiring some 15 to 20 points less elevation, and with a wind allowance of little more than half that required by everyone else. Capt. Hardcastle tells us that the bullet was designed by Kynoch, Limited, at

their works at Birmingham, and that he was personally responsible for combining the pointed shape with the full weight of bullet. The next that was heard of this bullet was a wonderful shot made by Mr. Caldwell in Scotland, but with a barrel of .322-inch caliber instead of .303-inch. In the shooting for the Cambridge cup, at 900, 1000, and 1100 yards, Col. the Hon. T. F. Fremantle, who won the cup, used a pointed bullet and a .303-inch barrel, but with a specially long chamber. Further, on the second day, in the same competition, Col. Hopton used the pointed bullet, but with the ordinary-sized chamber, and, having once found the target, made extraordinary diagrams. Both these well-known rifle-shots and the one or two other competitors who also used this bullet fully confirmed the correctness of the claim advanced by the manufacturers—namely, that the bullet used, which weighed 220 grains and had a pointed nose, required not only very much less elevation, but also only about half the wind allowance. Capt. Hardcastle has for four years been working and experimenting, and is satisfied that the well-known theories of Bashford as to the shape of the nose of a bullet no longer apply. He contends that it is not the shape of the point or the curve of the shoulder, but the total length of the pointed part that has given the results, and he has been able to deduce the rule that the resistance of the air varies inversely as the square root of the length of the pointed head measured in calibers, so that, if the length is increased by 2 per cent, the resistance of the air is diminished by 1 per cent. Messrs. Kynoch are offering for sale three different bullet cartridges after this design:

Calibre.	Muzzle velocity.	Weight of bullet.	Weight of charge.	Maximum fixed sight range.
	F. S.	Grains.	Grains.	Yards.
.303	2,360	225	37	650
.375/.303	2,470	225	42	700
.322	2,430	250	43	630

They are loaded with "Axite," an explosive somewhat similar in appearance to the modified cordite known as M. D., but differing in essential particulars and containing special ingredients to increase the efficiency. It is claimed that these cartridges have a higher velocity, a flatter trajectory, greater power of retaining velocity over all ranges, increased maximum range, greater accuracy and less liability to be deflected by wind, and increased disabling power at all ranges.—*Army and Navy Gazette.*

THE EFFICACY OF THE POINTED BULLET.—The elongated bullet is not likely to find favor with the War Office, for it has the fatal fault of being too long to feed up from the magazine now in use.

Although this bullet only sprang into notoriety through its use at the recent Bisley meeting, the War Office had long had it under experiment, with a view to substituting it for the present Service bullet, and it is just possible that the undue prominence which is now being given to the subject in the columns of the dailies, may have influenced the War Office to arrive at a speedier decision than they would otherwise have done. Even then, their action in the matter has been rather belated, because more than two years ago what is practically the same bullet was adopted by the German government, in the Spitze--geschoss or "S" bullet, so called on account of its pointed shape. The German military authorities had previously been experimenting for some time with a view to increasing the muzzle velocity of their rifle to approximately 3000 feet per second, in order to ensure the flattest possible trajectory at decisive ranges, a consideration which they regard as of primary importance.

There were obvious objections to doing this by reducing the caliber of their rifle from 0.311 to 0.256 (or some smaller caliber), which would be the first method to suggest itself. Apart from the great cost involved in such a change, there are certain objections to a very small bore, and these are diminished wounding power and increased difficulty of cleaning and

keeping in order the interior of the barrel. The alternative solution was to improve the ballistics of the existing rifle, by a suitable modification of its ammunition, and it appears that this has been effected partly by the adoption of a more powerful charge (whether a new powder is involved is not quite clear), but mainly by the adoption of a new bullet, and hence the genesis of the Spitze-geschoss or "S" bullet. This bullet weighs only 154.3 grains, as against the 227 grains of its predecessor, or as against the 215 grains of our Lee-Enfield bullet. The reduction of 73 grains weight, coupled with the higher pressure given by the new charge, has apparently raised the muzzle velocity of the German Mauser from about 2090 f. s. to about 2900 f. s. An additional and by no means unimportant advantage secured by the reduction in weight of the bullet is that about 15 per cent more ammunition can be carried than heretofore.

It is this latter consideration that ought to have weighed with our War Office, and, indeed, it was thought to be the one thing that would incline them to favor the adoption of the new "S" bullet. Moreover, the trajectory of this new bullet, firing at 12 inches above the ground, is not more than 5 feet 9 inches above it up to 700 yards' range, whereas with our bullet and rifle the range under these conditions is only 550 yards. Our heavy bullet is slightly more accurate beyond 1000 yards, but this does not appear a great advantage when compared with that of more ammunition. Yet although in this instance the War Office has decided against the new pointed bullet, as used at Bisley, it does not at all mean that they have abandoned their search for one more suitable, which will conform to the size and shape of the present one as regards chamber space and length of bullet. They hope eventually to get a cartridge of the same length as the present Service one, capable of feeding up through the magazine, and with a bullet of some 150 grains and a muzzle velocity of 2800 feet to 3000 feet per second, as opposed to the 215 grains and the 2000 feet per second of the present form.

The greatest advantage given by the new "S" bullet of the German Army, in the matter of flatness of trajectory, is to be found between 500 and 800 yards. At 700 yards' range a man 5 feet 9 inches in height would, as we have shown, be hit anywhere along the range if the muzzle of the rifle were 12 inches from the ground, an effect our rifle could only produce at 550 yards. But there are two other points also affecting the military value of this bullet, and these are its wounding power and its penetrative effects. Taking the striking energy of the bullet as the measure of its wounding power, it would appear that the German pointed bullet is more effective than the Lee-Enfield up to between 900 and 1000 yards; but beyond that it is slightly inferior, although the difference is unimportant. In the matter of penetration the advantage certainly lies with the new bullet at all except extreme ranges.—*United Service Gazette.*

The "Elswick" separate vessel heater for torpedoes, to overcome the loss of heat due to the expansion of the air used in the propelling engines, is now being extensively applied to torpedoes at the Whitehead Torpedo Factory at Weymouth, and has given astonishingly successful results. In the case of the latest pattern 18-inch torpedo a speed of 28 knots for 2000 yards, or 34½ knots for 1000 yards, is maintained when using the ordinary cold air. For longer distances, such as 3000 and 4000 yards, the speed, of course, is proportionately less, falling to about 20 knots for the 4000 yards range. When using the "Elswick" heater the same torpedo maintains a speed of over 40 knots for 1000 yards, 37 knots for 2000 yards, 30 knots for 3000 yards, and 27 knots for 4000 yards. These speeds are quite extraordinary, as they represent exactly 100 per cent more power from the engine; and when it is further pointed out that the "Elswick" heater is extremely small, simple, and burns any ordinary lamp-oil, and is capable of being fitted to practically any existing type of torpedo, the effects of it are such as cannot fail to command the serious attention of all countries using the Whitehead torpedo. The Admiralty have never been slow to adopt

improvements in the torpedo armaments of the fleet. For years Great Britain has led in the matter of submerged tubes for firing torpedoes, and in all probability our fleet exercises more with torpedoes than that of any other country; consequently an improvement of the kind described is of more value to our navy than to any other. The general principles of the new heater are that the air is heated by burning with it oil-fuel after it has passed the usual reducing-valve. The reducing-valve is consequently a measure of the pressures produced by combustion, and automatically controls the air and fuel supply, thus making no difference in the evenness of the speed obtained when running cold, or hot, and producing, what has hitherto been lacking in all other forms of heating devices, a constant temperature irrespective of the quantity of air or fuel used. The whole apparatus adds only a few pounds weight to the torpedo, and is absolutely safe and simple to manipulate.—*Engineering.*

AN INTERESTING EXPERIMENT AT GAVRES.—The following experiments have been carried out at Gâvres to throw light upon the cause of the Jéna accident.

A caisson was constructed, having the same shape and dimensions as the 10-cm. magazine which exploded on the *Jéna*, and fitted with a similar ammunition hoist. In this structure were placed 270 10-cm. shell loaded with black powder, their B powder cartridges, and fifteen 10-cm. melinite shells; alongside of it, as on the *Jéna*, was a black powder magazine, only instead of putting in the latter the large quantity of black powder which was in the *Jéna's* magazine, small lots of this powder were placed where the time of their explosion could be noted by observers.

The object was to determine the effects which would be produced by setting fire to the B powder in one of the cartridge cases in a magazine; would the B powder simply burn up, without explosion and without causing a general conflagration in the magazine, or would it cause an explosion like that on the *Jéna?*

The first part of the test was carried on in the open air and consisted of setting fire, by electricity, to cartridge cases loaded with B powder, having the point of inflammation sometimes at the front end of the cartridge and sometimes at its rear end near to the black powder ignition charge. Each time that a cartridge was lighted near its front end, the B powder simply burned. When the ignition was near the rear end, there was an explosion bursting the cartridge case.

In the second part of the test, when the structure above described was used, first a B powder cartridge situated near the upper part of the magazine was ignited at its forward end: it burned up without noise or any other result. Then another cartridge of B powder, in just the same position, was ignited, but this time at its rear end; a sharp explosion was heard, not very loud; then, after about 10 seconds, a sound like that of high pressure steam escaping from a boiler which has been damaged, increasing very rapidly and almost immediately accompanied by a great outburst of flame, through the ammunition passage principally; almost immediately after this shells began to burst in rapid succession, showing by their black smoke that they were melinite shells; then, for nearly two hours there were occasional explosions at varying intervals. Fourteen minutes elapsed after the setting fire to the first cartridge of B powder before the black powder in the adjoining magazine was fired.

On the *Jéna*, it was at 1.40 p. m. that, through the decomposition of B powder, one of the cartridges loaded with that powder was spontaneously ignited, probably at its rear end where the ignition charge is placed, whence resulted a general inflammation of the ammunition, just as happened in the experiment; bursts of flame from the after part of the ship, successive explosions of the shells in the B powder magazine; then, about 10 minutes later, the great explosion due to the communication of fire to the black powder magazine.

A further proof that this is what actually took place on the *Jéna* is that an examination of her wrecked magazines showed that the bulkhead separating the one containing B powder from the one containing black powder was covered, especially in its lower part, with the marks made by fragments of exploding shell which had struck it before it was blown down by the black powder explosion.

In the experiment, just as on the *Jéna*, a number of the projectiles did not burst.—*Moniteur de la Flotte.*

The ordnance department of the army has been conducting at the Springfield armory comparative erosion tests of two samples of powder. The cartridges were loaded for 2700 feet per second muzzle velocity. The powders used were the pyro-cellulose sample No. 7, and regular .30 caliber composition No. 11 (nitro-glycerin). The velocity obtained with both powders at the beginning of the test was very low, but that may be partially accounted for by the fact that the firing was made immediately after the receipt of the powder when its temperature was considerably lower than in the subsequent firings. The pyro-cellulose powder showed up much better than the nitro-glycerin in regard to velocity, although the variations were somewhat greater. The star gauging showed that the rifle using the pyro-cellulose was much less eroded than the one using nitro-glycerin powder. It was regretted that the results of the accuracy of firing did not show any marked difference between the two powders, but may have been due to a bulge noticed when the firing had been brought up to 2600 rounds in the riflle using the pyro-cellulose powder. The test was duplicated with the two rifles from which were fired cartridges loaded for 2700 feet per second muzzle velocity regular nitro-glycerin composition, two using a special nitro-glycerin powder containing but 10 per cent of nitro-glycerin and two others firing pyro-cellulose powder. After 3500 rounds the tests with both the nito-glycerin compositions were discontinued. After 4500 rounds the pyro-cellulose powder had not appreciably eroded the two barrels from which they were fired. The special composition showed much less erosive effect than did the regular, and if a supply of cartridges had been on hand this rifle might have been fired perhaps 500 rounds more. At the end of 4500 rounds with the pyro-cellulose powder the firings were discontinued, due to lack of ammunition. It seems probable that the accuracy-life of a model of 1903 rifle using pyro-cellulose powder loaded for 2700 feet per second muzzle velocity will be in the neighborhood of 8000 rounds. Due to the excellent results obtained with this powder it will be adopted for the service, and as soon as a supply can be obtained the loading of model of 1906 cartridges will be commenced. A comparison of the above results with those obtained from previous firings was made. For this purpose an erosion test of the model of 1903 rifle, caliber .30 chambered for model of 1906 ammunition and having grooves deepened for 14 inches from muzzle, was made, 2600 feet per second model of 1906 ammunition used. The erosion after 2936 rounds near the bullet seat was much worse than with the pyro powder, and somewhat worse than with the nitro-glycerin.—*Army and Navy Register.*

GUN DEAFNESS IN THE NAVY.—That medical officers are not giving that close attention to the subject of gun deafness in the senior service which the subject deserves there is, unfortunately, ample evidence. There are signs, however, that a few naval surgeons, and also the Admiralty, are becoming aware of the alarming extent to which gun deafness at present prevails, and to which it is likely to increase in the near future if proper preventive measures are not at once adopted.

To keep the crews of our warships up to the present high standard of shooting efficiency it is necessary to expend a very large quantity of practice ammunition. Most of this ammunition is fired from the aiming rifles and small-bore guns of the navy, in order to combine economy with efficiency by making the smaller weapons do the same work in training hand,

eye, and judgment, as could be achieved by firing larger guns with more expensive charges and projectiles. On many days of each quarter, therefore, the ears of the fleetmen are constantly assailed with the snap of the Morris tube, the crack of the .303 rifle barrel, or the sharp ring of the three-pounder, six-pounder, or twelve-pounder gun, to say nothing of the "blast" of the havier guns when the regular practices are being carried out with all hands at their quarters, or with training classes firing their prescribed number of individual rounds. In one way or another, therefore, the ears of the officers and men are subjected to a very trying ordeal in a modern man-of-war. It is an unfortunate fact that the smaller guns, which are mostly used for instructional practices, are likewise the weapons whose report does most damage to the ears. Of course if a man is standing within the field of "blast" when larger guns are fired, his hearing is sure to be seriously affected, although the guns' crews in the turrets and casemates have but slight shocks from the discharge of their own guns, the turret gunlayers alone suffering to any extent from such discharges. But the peculiar ring from the small quick-firing guns, which sets up a singing noise in the ears, appears to have a wider area of harmful action, and as the crews of these guns are in the open when arranged around their guns, the ordeal of getting through a series of rounds is not a little trying, and undoubtedly has an injurious effect on the ears of the guns' crews, as well as of others who have to perform duties in close proximity to the spot where firing is being carried out.

The harmful results could, however, be considerably modified if those who are exposed to the shock of large or small gun-fire would take the simple precaution of plugging up their ears. But in the navy this act has always been regarded as a sign of effeminacy, and as such has been ridiculed and largely laughed down, sailors as a class being peculiarly sensitive to anything that is held to be taken effeminacy. Consequently, only the very morally courageous characters among the officers and men have had the good sense to preserve their hearing at the price of a few cheap sneers from their shipmates or gunmates. In a few cases only have officers of quarters actually forbidden the placing of cotton wool or oakum in the ears to protect them, although it has been largely discouraged by precept and example by all officers from the captain down to the midshipman.

The reason for this is obvious, for a man with his ears plugged would be thought by his superiors to be far less able to hear and quickly obey orders. But in nine cases out of ten this is a fallacy, for the men who may have not protected their ears are generally much less able to catch orders quickly between the rounds of firing (after three or four shots have been fired in rapid succession) than are the men who have protected their tympanums from numbness by placing effective plugs in their ears. The mistake is a very common one, and the majority of officers have yet to realize that the men should be encouraged to plug their ears, even if the voice has to be raised a little in giving them the necessary orders while firings are actually in progress.

It is to the interest of the navy and the nation that the hearing of our fleet men should be protected and kept as perfect as possible, so as to prevent failure in hearing orders, and obviate misunderstandings and mistakes that may arise from imperfect hearing. The prevalence of partial deafness in the navy is little short of alarming, and therefore its prevention should be taken in hand at once, for out of 50 men recently examined by a comparatively easy test, more than half of them were shown to be partially deaf, which state of affairs had, in all probability, been brought about by the firing from guns at which they had stood up as part of the crew.

The Admiralty are to be credited with the best of intentions, and they seem to be aware of the evil of gun deafness, for they have already taken steps to protect the ears of the guns' crews on board ship by means of "blast screens" composed of steel and india-rubber. But this is not enough. What we urge them to do is to go a step further, and see that

ear-plugs are provided and used. The Japanese used ear-plugs right through their last campaign, and it is a good sign that the staff officers of our own naval gunnery schools, who superintend much gunnery practice, are adopting the cotton-wool plug, and thus setting their men a beneficial and necessary example in protecting the essential sense of quick-hearing which all naval gunners should possess.—*United Service Gazette.*

MARINE TURBINES AND GAS ENGINES.

LATEST RESULTS WITH MARINE TURBINES.—Because of the vast amount of experience which has been gained by the Parsons Company, as the pioneers and largest manufacturers of marine turbines, any statement made by the Hon. Charles Parsons as to the actual results obtained with this new form of marine engine, is necessarily of great value. In a recent paper read by the inventor before the Institution of Civil Engineers, he has summarized results and answered several questions as to present efficiency and probable future developments of the marine turbine. The turbines at present in use may be comprised under three principal types: First, the compound type, which was first commercially applied in 1884, and comprises the Parsons, Rateau, and Zoelly. All of these adopt a line of flow of the steam generally parallel to the shaft. Mr. Parsons states that one chief object in his type of turbine has been to minimize the skin friction, by reducing the extent of moving surface in contact with the steam; another object has been to reduce the leakage by the adoption of a shaft of large diameter and great rigidity, so as to secure small working clearances over the tops of the blades. The second, or single-wheel type, of which the De Laval is the chief representative, has been used extensively on land for small and moderate powers; but, because of its high angular speed and the necessity of reduction gear on the screw shaft, it has received but little application for marine propulsion. The third, or sinuous-flow type, of which the Curtis turbine is the chief representative, ranks second to the Parsons in the extent of its use for marine purposes. It may be generally described as semi-compound, with a few stages of expansion, at each of which the De Laval expanding-jet principle is used. According to Mr. Parsons, the skin friction in the blades themselves, owing to the sinuous course at high velocity, is greater than in any of the varieties of the compound type.

The figures given of the total amount of horsepower installed in marine turbines show that the Parsons type has an almost exclusive command of the field, the total power at present in service being divided as follows: In pleasure steamers, 18,200; cross-channel steamers, 149,900; yachts, 18,100; ocean-going steamers, 91,900; and war vessels, 106,900; making a total of 385000 horsepower. The total power of marine turbines of the Curtis, Rateau, and other types, completed, is about 16,000 horsepower.

On the important question of consumption of coal in turbine vessels, Mr. Parsons states that, in fast pleasure steamers and cross-channel boats, the economy has been found to be from 5 to 15 per cent superior to that of similar vessels equipped with triple-expansion-reciprocating engines, and about 25 per cent superior to that of vessels propelled with compound paddle engines. To this advantage must be added others, such as the saving in cubical space, reduced consumption of oils and stores, and reduced work for the engine-room staff. It is well known that there is a critical speed of ship, below which the economical advantage of the turbine disappears. We are informed in this paper that for speeds down to about 16 knots, turbines have been found equal or superior in economy to reciprocating engines; and in some cases, where large and comparatively costly turbines have been fitted, as in the case of yachts, this advantage is maintained down to speeds of about 12 to 15 knots.

A noteworthy admission by Mr. Parsons is that the solution of the problem for slow vessels lies in a combination of reciprocating engines and tur-

bines; the reciprocating engines dealing with the high pressure of the expansion, and the turbines with the low pressure. He estimates that a combination of this kind, used in an intermediate liner of 15 knots speed, will effect the saving of 12 per cent in fuel over the best quadruple-expansion engines, and that there will be a reduction of total weights. In a large vessel of 10 to 12 knots speed the dual motive power would show a saving of 15 to 20 per cent in fuel over the best triple-expansion reciprocating engines; and, although in some cases the first cost will be greater, it is estimated that, because of the increased earning power of the vessel, the excess will be recovered in less than three years. In the larger vessels, however, there will be little or no increase in the capital cost.—*Scientific American.*

With a view to obtaining all the advantages of a great range of expansion and a high vacuum, which are marked characteristics of the turbine, the White Star Company has placed an order with Messrs. Harland & Wolff to build the first of two large steamers for the transatlantic trade, which are to be driven by a combined reciprocating and turbine engine plant. Power will be developed on three shafts, the outer two of which will be driven by quadruple-expansion reciprocating engines, and the central shaft by a low-pressure turbine, operated by the exhaust steam from the low-pressure cylinder of the reciprocating engines. For going astern the reciprocating engines will be used, while in ordinary service all three engines will be driven in combination.

Further advantages of this installation are that there will be separate steam connections from the boiler room to each of the three engines, so that in case of disablement, the vessel can be driven under the reciprocating engines or even by one of them alone, or by the steam turbine alone, live steam in this last case being fed direct to the turbine. The range of expansion will be increased, since it will be possible to use a higher pressure steam in the reciprocating engines than is found to be economical for steam turbines; while, on the other hand, the turbine end of the expansion can be carried down very much lower and with a higher vacuum than is possible in the reciprocating engine alone.—*Scientific American.*

Those persons who have recently been writing about defects in the machinery of the *Dreadnought* because that vessel has been undergoing a series of trials with different propellers will do well to study the discussion which took place at the Conference of Civil Engineers on the subject of turbines *versus* reciprocating engines for marine work. Papers were read on these subjects by Mr. C. A. Parsons and Mr. Henry Davey, the former dealing with turbines as applied to marine propulsion, and the latter with the advantages of the reciprocating engine for ocean-going steamers. In the course of the discussion Sir William White said that on land the turbine had at maximum power shown itself to be more economical in steam than the best type of marine piston engine, and he believed these advantages would hold good in the case of the marine turbine, concerning which he had information which he was not at liberty to make public. There appears to be generally a decided opinion in favor of the turbine, certainly for high-speed vessels, but for vessels in which a moderate speed only is required it seems probable that some combination of piston engine and turbine may prove to be the most economical arrangement. On the other hand, there is evidently considerable difference of opinion as to the form of screw propeller to be used with the high speed turbines. Sir William White, referring to the statement that the turbine called for the use of a less efficient screw than did the reciprocating engine, said it had to be remembered that the turbine-driven propeller was in its infancy, and some allowance should be made for the comparatively small experience with turbine-driven screws. It must be recalled that for over half a century various types of propellers have been tried with reciprocating engines, and

yet engineers differ as to which design is the best; the marine turbine has hardly been under trial for a fifth of that time, it can surprise none, therefore, if there should exist a desire to try several kinds of screw propellers in the hope that with the experience thus gained the most efficient type may be discovered.—*Army and Navy Gazette.*

TURBINE STEAMERS FOR THE MEDITERRANEAN.—The Fairfield Co., at Glasgow, has recently launched the first of two high-speed turbine steamers being built for the Egyptian Mail Steamship Co., and intended to inaugurate, in the late autumn, a new express service between Marseilles and Alexandria. These new ships, named *Heliopolis* and *Cairo*, are of great size, equalling the largest of the Atlantic liners of a few years ago. Their length over all is 545 feet; their breadth, 60 feet 3 inches; and their depth, from keel to shelter deck, 38 feet. The tonnage is 12,000 tons. The machinery, which is of the Parsons turbine type, will develop 18,000 horsepower when three turbines and three propellers are running at 340 revolutions per minute. This is to give the speed of 21 knots already referred to. The hull is divided by water-tight bulkheads into ten compartments, and there are seven decks.—*Nautical Gazette.*

THE MARINE STEAM TURBINE.—It is reported that in the early days of the Royal Society, King Charles II posed the Fellows with the conundrum as to why the addition of a live fish to a bowl of water caused no increase in the total weight of this bowl and its contents. The interesting problem thus submitted is said to have given rise to animated debate, various explanations being proffered. Had not the society been the corporate representative of the "new philosophy," the discussion might have continued as learnedly and indefinitely as that of the mediæval schoolmen on the equally nice point as to the number of angels which could find accommodation on the point of a needle. Appeal to experiment, however, being the essence of the "new philosophy," it was gravely decided to submit the supposed phenomenon to actual test, with the natural result of establishing its non-existence. We are reminded of this historic incident by the numerous explanations which have been advanced to account for the presumed fact that turbine steamers lose speed in a seaway to a greater extent than ships fitted with reciprocating engines. Quite plausible reasons can be found as to why turbine steamers should labor under this disadvantage; but, after all, it is well to be certain that they really do so before much time and energy are expended in divining a sufficient cause for the presumed disability.

Unfortunately, the general engineering public cannot submit the point in question so easily to the test of experiment as in the case cited above, since commercial considerations have led to great reticence, both in the case of builders and owners, as to the actual results obtained with turbine boats on service. Undoubtedly, however, the widespread conviction as to the inferiority of the turbine steamer in this regard has originated in the talk of the navigating and engineering staffs of these vessels, and it is difficult, therefore, to believe that it is entirely without foundation.

On the other hand, Mr. R. J. Walker, in replying to the discussion on his recent paper presented to the Northeast Coast Institution of Engineers and Shipbuilders, was able to show that in some instances, at any rate, the turbine-boats have exhibited a remarkable superiority to their rivals, in the very point under discussion. Last winter, he states, the twin-screw Channel steamer *Sussex* was, owing to stress of weather, unable to leave Dieppe till about 12 hours after her proper time. Two and a half hours after she had started, the *Brighton*, which is a turbine steamer, also left Dieppe, and her passengers caught the same train to London as those of the *Sussex*. It appears, in fact, that no matter what the severity of the weather, the turbines do not require to be eased, and are not eased save on direct orders from the bridge, dictated by the necessities of the ship, and not

those of the engine-room. On the other hand, as is well known, it is necessary to slow down, and stand by, with reciprocating engines in very bad weather, or they might be wrecked by the racing of the propeller. Possibly an explanation of the contradictory reports which are prevalent in this regard may be found in the turbine being superior in really heavy weather, but losing speed as compared with its rival in more moderate seas.

Another factor in the question which may be at least partially responsible for the prevalent opinion is that in service the turbine-boats never show the same superiority over sister vessels in the matter of fuel economy as they have done on trial. The principal reason for this would appear to lie in the circumstance that at full speed reciprocating engines are being overdriven, while in the case of every turbine ship, of which data have been published, it is obvious that even at full speed the turbine is still far from exerting its maximum power, and could easily dispose of more steam if it were forthcoming from the boilers. Further, as marine turbines are always under-speeded, the faster the ship travels the more economical does the turbine become, so that on trial it is working at its best efficiency, while the reverse is the case with the reciprocating engine. The full advantage is never obtained from running the turbine more nearly at its correct speed, independently of propeller considerations. It is certainly possible to maintain it at its full speed of revolution, however bad the weather, as emphasized by the Hon. C. A. Parsons before the Institution of Naval Architects at Bordeaux in June, 1907, but if it should exceed this speed by a small margin, the automatic cut-out would come into action, an occurrence which never happens in service. Hence this source of efficiency is eliminated, and the full effect of the over-speeding of the screw due to the greater slowness of the ship is felt on the steam consumption.

At the Engineering Conference Prof. Biles stated that in smooth-water trials the Midland Railway Company's turbine boats showed an economy of 15 per cent in steam consumption, as compared with the sister vessels with reciprocating engines, although no difference appeared in actual service. His explanation was that the extra revolutions demanded to maintain speed in rough water loaded the screws beyond the cavitating point. With the large screws of reciprocating engines this effect did not occur, and if turbine vessels were fitted with larger screws, although the trial-trip efficiency might be reduced, better results would be obtainable in every-day work. If this view be correct, and the propeller losses increase so much more rapidly than the efficiency of the turbine increases, for the same speed of the vessel, it certainly seems that the propellers are worked too near their limits of thrust. Sir William White pointed out that falling-off of speed had also happened with reciprocating engines; but the cases are not strictly comparable, as we have pointed out above. As regards efficiency, it is stated that H. M. turbine cruiser *Amethyst* is doing better than her sister ship the *Topaz*, with reciprocating engines, and she certainly gave better trial results; but, on the other hand, the German turbine cruiser *Lübeck* has proved consistently worse than the *Hamburg*. It is said, however, that other factors enter into this last comparison.

The extent to which ships have been "over-turbined" has been very remarkable. In the case of the *Dreadnought*, the official figures show that her turbines could easily develop 20 to 25 per cent more power than that obtained in the nominal full-power trial, and still have the inlet pressure not higher than it would be in the steam-chest of a reciprocating engine working with the same boiler-pressure. In the navy, since the introduction of water-tube boilers it has been usual to generate steam at, say, 250 pounds pressure, and reduce this to 200 pounds at the engines, a reserve thus being provided, which greatly facilitates station-keeping. In the *Dreadnought*, however, the reduction was nearer 100 pounds than 50 pounds, and, as Mr. Griffith stated at the conference, the torque on the shafting is nearly proportional to the inlet pressure of the turbines. That the practice of "over-turbining" is not confined to the navy would seem to be borne out by the statement, recently published, that at the late over-

haul of the *Carmania* an attempt was made to reduce the steam-way through the turbine by twisting the blades to a more acute angle. This expedient might work fairly well in the case of an electric-light turbine, which is usually not greatly under-speeded, but seems somewhat questionable when applied to the conditions of marine practice, as it must materially increase the losses by shock.

We are unaware as to the considerations which have led in so many cases to the provision of turbines so far in excess of the actual requirements of the ships to which they have been fitted. Partially, perhaps, the practice has originated in the methods used for proportioning the turbines, which are understood to be largely of "the rule-of-thumb character." This belief finds confirmation in Mr. Gerald Stoney's statement at the Engineering Conference—that an efficiency ratio of 78 per cent was attained in the recent test at Carville Power Station, particulars of which were published in *Engineering*, May 17 last, page 654 *ante*. From the data given it is obvious that the figure stated has been obtained in a purely empirical fashion, the actual efficiency rated being certainly under 70 per cent.

Perhaps one of the most important pronouncements made in the recent conference was that in which Sir W. H. White expressed his belief in the ultimate discovery of an efficient form of high-speed screw-propeller. His unrivaled experience gives him a right to express an authoritative opinion on this matter, and we sincerely trust that he is not unduly sanguine. The day which witnesses the development of a propeller capable of efficiently developing a large thrust at a really high speed of revolution renders obsolete the ordinary marine engine. In the case stated it would not survive even in the modified arrangement now proposed for slow-speed vessels, in which an exhaust-steam turbine is to take the place of the low-pressure cylinder. As matters stand, this proposal yields promise of a very substantial fuel economy, but we fear it will, in spite of its merits in this regard, be deemed by many as a somewhat inartistic makeshift.

For larger and faster vessels superheated steam may ultimately come into general use. The fact that for a given pressure the volume of the steam is very substantially increased has some advantages from the theoretical standpoint, since longer blades would be in order at the high-pressure end, thus reducing the ratio of the clearance to the height of the blades. It is generally understood, however, that in practice this has not hitherto proved possible, and that, on the contrary, the use of highly superheated steam has necessitated an increase of clearance, so as to avoid the risk of the blades fouling the casing through unequal expansion. If the superheat could be maintained with sufficient steadiness, this necessity would not arise; but as matters stand, many "strips" have arisen solely from a too sudden change in the temperature of the supply of superheated steam. On land such "strips" are annoying, but involve little danger; but at sea conditions are different, and Mr. Parsons' reluctance to sanction the use of superheated steam there is accordingly very easily intelligible.—*Engineering*.

THE TRIALS OF THE LUSITANIA.—The Cunard liner *Lusitania* has met the most sanguine anticipations of all concerned. At a draft of 30 feet she has steamed over 26 knots on the measured mile; on a 48 hours' sea run on long measured distances she has maintained a mean speed of 25¼ knots. The contract anticipated a speed of 24½ knots on the round voyage on the Atlantic, and this will be easily achieved.

Justification for this view is found in the fact that the long-distance trial represented exactly the conditions of the Atlantic voyage. The unprecedented length of the trial precluded "jockeying." The course of about 300 miles was traversed four times in alternate directions, so as to eliminate the influence of tide and weather. It is unnecessary to say that the machinery worked satisfactorily. The general result stated carries conviction from this point of view. Before entering upon this, the most cru-

cial test, the *Lusitania* had made several preliminary trials on the Clyde measured mile, not only to tune up the turbine machinery, but to standardize the relation between revolutions, power, and speed, so that a series of trials could be made to determine the coal consumption at various speeds. These economy tests began when the *Lusitania* left the Clyde for a cruise around Ireland. The vessel was loaded to a draft of 32 feet 9 inches, equal to a displacement of 37,000 tons, and on the cruise the water and coal consumptions were taken while the vessel ran for six hours at speeds of 15, 18, and 21 knots respectively. The results were thoroughly satisfactory, but the data obtained were in connection with service requirements rather than scientific purposes.

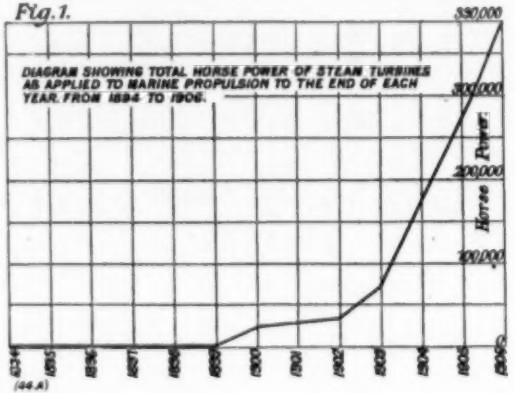
The guests having been transferred to the tender at the Mersey Bar, the more exacting tests were entered upon, water and coal consumption data at 23 and 25 knots being taken. On the run to the Firth of Clyde, the starting-point of the full sea-speed trials, the course measured out on the chart was between the Corsewall Light on the Wigtownshire Coast to the Longship Lighthouse at Lands End, and this had to be traversed four times, alternately north and south. The compass bearings gave the distance, which aggregated about 1200 miles; the trial began at midnight on Monday, and ended about 1 o'clock on Thursday morning. The weather was favorable, with cloudless days and starlight nights; but on both nights northwest winds freshened to forces of six and eight, and although this occurred when the vessel was steaming north, and somewhat increased resistance and slightly reduced speed, it brought consolation in the fact that it prevented fog. The feature of the trial was the uniformity of the speed on both runs south and on the two runs north, the latter being against the wind and tide. The course, as a glance at the chart would show, was divided into three approximately equal parts by the Fodling and Tuskar lights. Compass-bearings taken at these intermediate points proved the uniform rate of steaming. The time taken on the runs south differed by only two minutes; further proof is unnecessary of the great regularity of steam-supply or of turbine efficiency. The speed on four runs was: South, from Corsewall, 26.4 knots; north, from Longship, 24.3 knots; south, from Corsewall, 26.3 knots; north from Longship, 24.6 knots; mean speed, 25.4 knots.

This is a great performance; it exceeds by two nautical miles per hour any similarly long run made. The truest significance lies in the uninterrupted mechanical precison with which every unit of the machinery worked. The air pressure in the ashpits of the boilers did not at any time reach the maximum of ¾ inch prescribed in the specification by the Cunard Company. The boiler pressure averaged 186 pounds per square inch, while the pressure at the receiver of the high-pressure turbines varied little from 150 pounds; at the low-pressure receiver it was 3½ pounds. The mean vacuum was 28.2 inches, with an average barometric reading of 29.8 inches. The mean revolutions of the four shafts were 188 per minute, and the power, according to the torsionmeter, was 64,600 horsepower. To those not versed in the details of steam-turbine performances the fact is illuminative. The circumferential or tip velocity of the rotors of the low-pressure turbines was 150 feet per second, equal to over 9000 feet per minute. The general procedure in the machinery department accorded with Atlantic practice, and Tuesday's and Wednesday's performance might to all intents and purposes have been two days running, each equal to over 600 miles, on a voyage to New York. This will certainly be the condition a month or six weeks hence. On returning to the Clyde the vessel proceeded on shorter distance tests, while following this were progressive runs on the measured mile; these ranged up to 26 knots.

The steering qualities of the vessel have also been tested. When steaming at 15 knots the rudder was put from amidships to hard over, both to port and starboard, in 15 seconds, and the full circle was completed in 8 minutes. Immediately before commencing to turn, the engines were running at the rate of revolution which gave 15 knots. A careful record of

" Nothing is more clearly indicative of incompetence in Naval matters than the belief that it is economical to let others bear the expense of testing and developing new ideas " (L. E. Bertin).

Fig. 1.



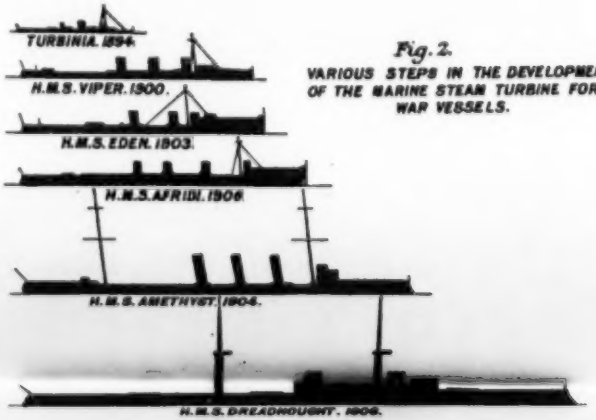


Fig. 2.
VARIOUS STEPS IN THE DEVELOPMENT OF THE MARINE STEAM TURBINE FOR WAR VESSELS.

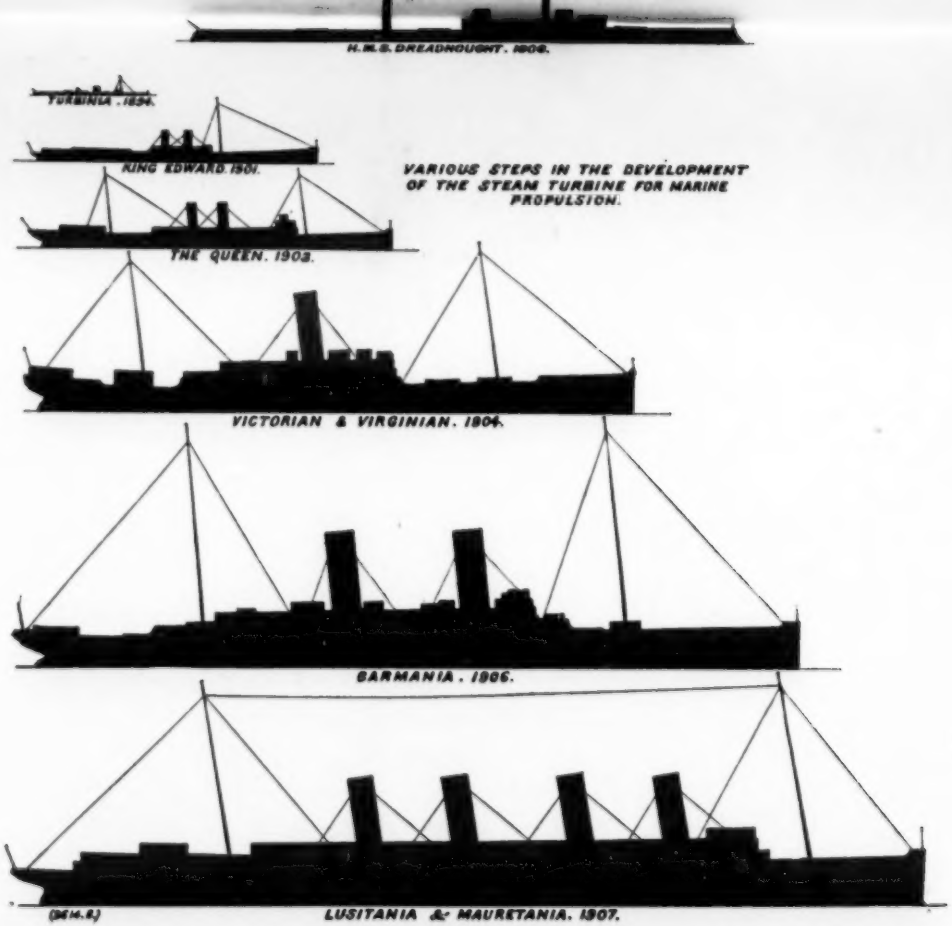

H.M.S. DREADNOUGHT. 1906.
TURBINIA. 1894.
KING EDWARD. 1901.
VARIOUS STEPS IN THE DEVELOPMENT OF THE STEAM TURBINE FOR MARINE PROPULSION.
THE QUEEN. 1903.
VICTORIAN & VIRGINIAN. 1904.
CARMANIA. 1905.
(SEMI-R.)
LUSITANIA & MAURETANIA. 1907.

FIG. 3.

revolutions was made on a time basis during the evolution, and it was found at the completion of the circle that the rate of revolution was then 70 per cent of the rate at 15 knots. The final speed was thus assumed as 10.5 knots, the average speed 13 knots, and the diameter of the circle about 1100 yards. This for a ship of this great length is a most satisfactory performance; the ship, at 22 knots, made the complete circle in 7½ minutes, with 15 degrees of helm. In ordinary steering the ship answered her helm very rapidly, according to the testimony of the pilot, and her swing was easily checked. Although the weather was very fine, alike on the 36 hours' run around Ireland and on the 48 hours' trial on the deep-sea course, there was sufficient swell on the Atlantic in the first-named trip, and between the Tuskar and the Longship Lights on the subsequent runs, to cause pitching and rolling motions to be perceptible. The period of a single roll from side to side was 10 seconds, and of a pitch four seconds.—*Engineering.*

THE PROSPECTS FOR LARGE MARINE GAS ENGINES.—Confidence in the probable use of internal combustion engines for propelling large vessels is not shared by all. An eminent English marine engineer, Francis E. Elgar, in a paper read recently at the Engineering Conference held at the Institution of Civil Engineers, London, was extremely skeptical that such applications would be made, at least for some time to come. His paper included a recapitulation of the characteristics of efficiency, safety, and economy, which must be developed and united in this type of engine before it can be successful in marine use on a large scale. His summary, which is worthy of careful consideration, follows:

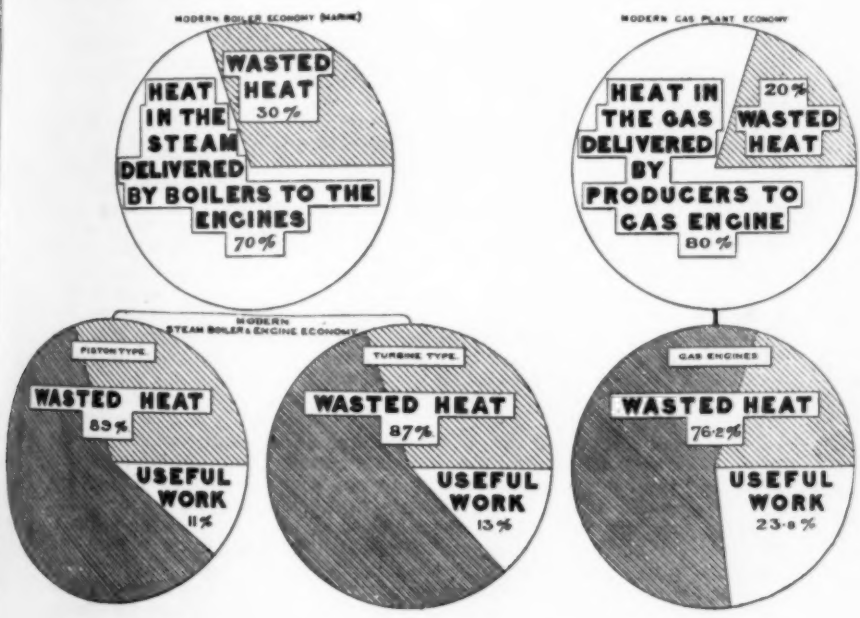
1. The engine must be reversible.
2. It must be capable of being quickly stopped and started, either ahead or astern.
3. It must be capable of being promptly accelerated to any speed between dead, slow, and full speed, and of being kept steadily at the required speed for any length of time. "Dead slow" ought not to be faster than one-quarter of full speed, and should be less in very fast vessels
4. It must be capable of running continuously for long distances, with but short intervals between the runs, without risk of stoppage and breakdown.
5. It must be capable of working well in rough as well as smooth water, or in a seaway in which the variable immersion of the propeller causes fluctuating resistance.
6. All working parts must be readily accessible for overhauling, and all working parts must be capable of being promptly and easily adjusted.
7. The engine must be economical in fuel, especially at its ordinary working speed.
8. It must be compact, light in weight, and well balanced, so as not to cause vibration.
9. It must not involve any risk of accumulation of gas in the ship, such as to form an explosive mixture.
10. Above all, it must be capable of using a fuel whose supply at moderate price is practically unlimited and can be readily obtained in any part of the world a ship might visit.

Referring to published plans for installing gas and oil machinery in 16,000-ton battleships, Mr. Elgar maintains that "this exists at present in imagination only." "It is impossible," he continues, "for any one to judge by what has been achieved up to the present in this direction, what weight or space, or what consumption of fuel would be required for the internal combustion engines of greater power, that might, perhaps, ultimately be made to fulfill the onerous requirements of marine work. Engineers and metallurgists may, by working together, succeed some day in overcoming the difficulties of producing large cylinders which will stand the high impulses and great and rapid variations of temperature that occur with internal combustion, but until this is accomplished no great step ahead has been taken."

There are those who will be inclined to consider this view extreme. Many installations of large internal combustion engines have been successful ashore. It is natural to be credulous that in the future engineers may solve the problems of any new branch of engineering. Many times in the past a few years has sufficed to contradict the most distinguished disbelievers.

Another paper read at the conference told of the progress made with the marine steam turbine, which has grown in its application from the tiny *Turbinia* of 1894 to the gigantic *Lusitania* and *Dreadnought* of to-day. A curve showing the total horsepower of steam turbines applied to marine propulsion has its beginning at zero in 1896, and its end at 390,000 horsepowers in 1906. It is doubtful if many engineers at the advent of the *Turbina* expected a turbine propelled *Lusitania* within 10 years. Repeated instances of the sort have bred a confidence in the world's engineering genius, that warrants hope for great ships propelled by combustion engines, in the comparatively near future, and cheaply, perhaps with crude oil, perhaps with alcohol or other clean fuel.—*Iron Age.*

EFFICIENCIES OF STEAM AND GAS POWER PLANTS ON THE RAND.—This interesting diagram was presented by Mr. Kenneth Austin at a recent meeting of the Transvaal Institute of Mechanical Engineers. The top diagram on the left shows the efficiency of the best boiler plant. Beneath are shown the best percentage values obtained in marine practice with multiple cylinder and turbine engines. On the right are gas producer and gas engine computations.


MODERN BOILER ECONOMY (MARINE)
HEAT IN THE STEAM DELIVERED BY BOILERS TO THE ENGINES 70%
WASTED HEAT 30%
MODERN GAS PLANT ECONOMY
HEAT IN THE GAS DELIVERED BY PRODUCERS TO GAS ENGINE 80%
20% WASTED HEAT
MODERN STEAM BOILER & ENGINE ECONOMY
PISTON TYPE
WASTED HEAT 89%
USEFUL WORK 11%
TURBINE TYPE
WASTED HEAT 87%
USEFUL WORK 13%
GAS ENGINES
WASTED HEAT 76·2%
USEFUL WORK 23·8%

WORKING EXPERIENCES WITH LARGE GAS-ENGINES. By Cecil A. St. George Moore.—The production of power by the use of large gas-engines has developed at a remarkable rate during the last few years, and much has been written on the subject.

The present paper has been written to show some of the defects which

have presented themselves in actual work, and by what means and to what extent they have been overcome.

No one type of engine has yet proved itself superior to all others. The engines built on the Continent can be classed under three main heads—viz.: (1) the double-acting four-cycle type, generally made in large sizes with tandem cylinders; (2) the Oechelhaüser type; and (3) the Körting type.

The value of positive scavenging in engines of the four-cycle type is still regarded as an open question. In most of the large Continental engines no scavenging is attempted, it being presumably thought that the results obtained are not worth the extra complication. Theoretically, it seems, however, that if the clearance space is full of pure air at the commencement of the suction stroke, a stronger mixture might be drawn in, and consequently an increase of power might be obtained with an engine of the scavenging type, as the air already in the cylinder would serve for the combustion of the extra gas drawn in.

The governing of gas-engines of the four-cycle type has received very careful attention from Continental engineers. The hit-and-miss method, which has been the universal practice for small engines, is satisfactory in sizes up to 2000 horsepower for driving direct-current dynamos. For driving alternators and other work where a steady turning moment is necessary, the plan most usually adopted is to provide a varying cut-off for the gas on the suction stroke, the gas and air valves opening together at commencement of stroke, the gas-valve closing at a variable point determined by the governor, and the air-valve remaining open until the end of the stroke. Another method of governing is to cut off the gas and air together at a varying point on the suction stroke, thus giving a mixture of constant proportions but variable quantity. At light loads, when the cut off is early, the pressure in the cylinder at the end of the suction stroke falls very much below atmospheric, and in order to prevent the valves being opened by the atmospheric pressure outside, a positive mechanism must be provided for keeping them closed.

There has been much to learn with regard to the design of the piston for engines of the Körting type. Owing to its great length and weight, it is difficult to make it a satisfactory and reliable job. If the engine is not fitted with a tail rod, the piston is generally a plain cylindrical casting.

With the heavy pistons used on the Körting engine, it is a very good thing to have the bottom shod with white metal, which takes up the wear, and which can be renewed from time to time; otherwise, if the whole weight of the piston rests on the bottom of the cylinder, the wear of the latter will be very great. The white metal should stand out about 1 mm. from the body of the piston. If the engine is fitted with a tail rod, the rod should either be continuous right through the piston, or the two rods should be bolted rigidly together. In no case should the cast-iron piston block be used as a connecting link between the two rods.

It is now the fairly universal practice to fit large double-acting engines with tail rods, but it is still an open question whether it is expedient to camber the rods so that the whole weight of the piston is taken by the guides. If no cambering of the rods is attempted, it is doubtful whether a tail rod is of any great advantage, at any rate for engines of less than 500 horsepower, and it is the author's experience that an engine of the Körting type will run quite well without one, provided that the piston is properly shod with white metal. The addition of a second stuffing box counteracts to a great extent the advantages of a tail rod.

The production of a good metallic packing forms one of the most difficult problems in gas-engine work. Cast iron has been found by experience to be, on the whole, the most satisfactory material, though it is very important that it should be very soft, and that the rings should be given very little spring on the rod, otherwise excessive wear will result. With an 8-inch rod it is quite enough if the rings are bored out 1/64 inch less than the diameter of the rod. In this case, after running about a month one or two of the rings nearest the cylinder will have become just slack on

the rod, but these can easily be renewed. The most satisfactory form of ring is rectangular in section, and should not be too narrow. This should be surrounded by an L-shaped solid ring, which is made an accurate fit inside the packing box. The box should contain eight or ten of these double rings which should be held up to their work by spiral springs, acting parallel with the rod. White-metal V-shaped rings may be used with advantage at the outside end of the packing, well away from the hot end. They should preferably be put in a separate box fitting inside the main packing box.

The correct timing of the ignition is a very important factor in the running of a gas-engine, if economical working is to be maintained. An arrangement for altering the timing while the engine is running should always be provided, and this should be calibrated with the help of indicator diagrams. The timing should be so set that the explosion line is vertical, not leaning back. Repeated experiments have shown that the maximum power is obtained with a vertical explosion line, the extra pressure thus gained during the early part of the stroke more than making up for the lower expansion curve.

One of the most persistent troubles which users of large gas-engines have to contend with is the liability to pre-ignition. Pre-ignitions are not in themselves dangerous provided they keep within limits. Pre-ignitions of the ordinary type are evidently caused by overheating of something inside the cylinder. If the piston rings are broken, and hot gas is blowing past the piston, the latter becomes overheated at the edge, causing pre-ignition. Pre-ignitions may also be caused by firing past the rings from one side of the piston to the other if the former are in bad order.

No installation of large gas-engines is complete without some means for utilizing the heat carried away by the exhaust. The most satisfactory way of doing this is to pass the exhaust through a boiler. The steam generated may be used for a variety of purposes, such as supplying the producers, heating, running a small steam engine, etc.

The relative advantages of producer gas as compared with blast-furnace gas for use in large engines have been much discussed. The author's experience is that Mond gas is quite satisfactory for large engines, if reasonable care is taken in its use. The gas must be thoroughly cleansed, otherwise trouble is bound to ensue, owing to the valves of the engines sticking. Mond gas contains an enormous amount of tar, which is very difficult to get rid of. Some kind of washing arrangement and two sawdust scrubbers in series are absolutely necessary. For washing purposes an old Lancashire boiler set vertically is useful. This should be packed with ring tiles, and the gas should pass upwards through it, water meanwhile dripping downwards over the tile and being carried away by a drain through a water seal at the bottom. This process, besides extracting a certain amount of tar from the gas, also cools it very effectively.

Even when the gas is in this condition, after a very short time the gas-valve and mixing chamber of a four-stroke engine, or the gas piston valve of a Körting engine, will become thickly coated with tar, and a thorough cleaning of these will be necessary about once a fortnight. The author has suggested that after cooling the gas to atmospheric temperature it should be heated again before being taken to the engine. This heating would make up for the fall in temperature during the suction stroke, and hence the deposition of tar would probably be avoided, and it would be carried over to the cylinder and there burnt. It has been frequently debated whether a gas containing a comparatively large percentage of hydrogen is suitable for large engines. A point which is often overlooked is that the temperature of combustion of hydrogen is considerably lower than that of carbonic oxide; hence an engine running on Mond gas should, theoretically, keep cooler than one running on blast-furnace gas. Against this we have to set the fact that hydrogen ignites at a lower temperature, and hence there is more liability to pre-ignition. The following is an average analysis of Mond gas:

CO_2	16.4%	H	26.6%
O	0.2%	CH_4	2.7%
CO	11.4%	N	42.7%

Calorific value (higher scale) 159.4 B. T. U. per cubic foot.

If the load on a producer-gas plant is suddenly largely reduced, gas of a very high value is given off for a short time, and this will cause violent pre-ignition, generally resulting in the engines pulling themselves up entirely. If, however, the driver is prepared, and, as soon as he sees the load begin to go up, keeps it steady by partly shutting off the gas at the stop valve, the temporary rise in value of the gas can be tided over without any trouble. This helps to explain the fact that large engines can be successfully run on coke-oven gas, provided that it is sufficiently diluted. An average sample of coke-oven gas gives the following analysis:

CO_2	5.0%	H	41.8%
O	0.6%	CH_4	33.3%
CO	5.6%	N	13.7%

Calorific value (higher scale) 517 B. T. U. per cubic foot.—*Technical Literature.*

RADIO TELEGRAPHY.

RECENT DEVELOPMENTS IN WIRELESS TELEGRAPHY.—After running rapidly over the early and important steps in the development of wireless telegraphy, Dr. Lee DeForest takes up in greater detail the more recent devices and improvements which have advanced this art. Among these devices are the electrolytic responder or "polariphone," the electrothermic receivers such as silicon and psilomelane, and the vapor receiver or "audion." The latter device is exceedingly reliable, and has excellent tuning qualities. The silicon receiver is interesting, since it does not require a local battery, the thermoelectric action set up by the received waves being sufficient to operate a telephone or other signalling device. The transmitting part of the problem has not made such satisfactory progress; in fact, but little has been done to explain the way in which the electrical waves are set up and radiated. Duddell and Taylor conducted some important investigations in this direction, but almost no progress has been made toward actually plotting the fields of force of these waves. However, it seems pretty well established that the energy of the electromagnetic wave varies inversely between the first and second power of its distance from the source. The wave therefore must not expand as the surface of a hemisphere, but of a hemisphere very much flattened. Many observed paradoxes are made clear by this theory, but there are a great many data to be collected and costly experiments to be made before the complete theory of overhead transmission and of varying conditions can be confirmed. One great desideratum is the discovery of a method whereby the propagation can be limited to any desired direction. Hertz's parabolic reflector is a clear solution, but only for waves of high frequency. The horizontal wave chute or artificial ground net is unable to solve the problem. Braun's work with several vertical transmitting antennæ is promising, but the accuracy demanded by this method has prevented its successful operation. The use of horizontal antennæ near the earth's surface is limited, because of the less distance attained than with the same length of vertical antenna. A compromise, in which an oblique antenna is employed, has given some valuable results. This phase of the problem is important, for it was found by the author in 1902 that a group of telegraph wires acts as a wave chute to confine a large amount of the radiated energy to a zone coaxial with such lines. In virtue of this effect, surprisingly long distances in transmitting wireless signals to trains have been attained. The author believes that this phenomenon offers to railway companies a means of keeping up their telegraphic service, even when the wires have been blown down by

a storm. Another great problem is that of selectivity or syntonization. Here the value of the so-called loose coupling between oscillating and radiating systems is recognized. The best-known circuits accomplishing this to-day are embraced in the Stone system, which prevent interference if the frequency differs but one per cent. This degree of selectivity is ample for commercial requirements, but no matter how loosely coupled an oscillating system and its antenna circuit may be, the trains of waves sent out through any oscillator utilizing the ordinary spark discharge are too rapidly damped to allow the full benefits of the system to be attained. To overcome this, continuous oscillations must be set up and perhaps the most promising work in this direction is that started by Duddell with the singing arc, and improved later by Poulsen, who enclosed the arc in a neutral atmosphere. The author then points out that, given a continuous radiation of undamped waves or a radiation of undamped wave-trains in groups whose frequency is above the audible limit, or at least above the frequency of the more essential tones used in human speech, wireless telephony over commercial distances is comparatively easy of realization. The receiver for this system is already satisfactory, as those at present in use reproduce every change in the character of the spark now employed in tansmitting wireless telegraphic messages. The author points out that for the transmission of radio-telegraph signals the medium required is ether at rest; that for radio-telephonic signals the medium should be ether in a continuous state of vibration. To vary the state of normal disturbances in the ether it suffices to vary the intensity of the spark itself, which is the origin of this disturbance; or to vary the intensity of the high-frequency currents. At the point of attachment to the earth these currents are greatest, the potentials are least, and this point is therefore the most sensitive and effective place in which to insert the intensity-governing device. This is a method on which Dr. DeForest is now working. He believes that radiotelephony has a wide field in all marine communication and between isolated points, in mountain and rural districts, in military field operations, and he ventures the opinion that if transatlantic telephony is ever accomplished it will be by means of the upper medium rather than by a submarine cable.—*Abstracted from the Journal of the Franklin Institute (Philadelphia), June.—Electrical Review.*

It is stated that a transatlantic wireless telegraph service will be opened by the Marconi Company in September. Messages will be transmitted from the station at Clifton, Ireland, to Cape Breton, Canada, at little more than half present cable rates. Signals have been exchanged between the stations in Ireland and Canada for some time with satisfactory results.—*Page's Weekly.*

GERMAN WIRELESS TELEGRAPH DEVELOPMENT.—The German official system of wireless telegraphy, the Slaby-Arco method, includes, it is stated, 20 stations in the United States. From Chemnitz, Germany, U. S. Consul Thomas H. Norton reports as follows regarding the system: "The number of stations equipped with apparatus of this system is now 641, or 41 per cent of the entire list of existing wireless telegraphic stations, numbering 1550. These have all been installed by one Berlin company, which controls a variety of patents in the leading countries on machines and accessories. These 641 stations are scattered over the territory or vessels of 31 different countries. Of these some 174 are located on land. They usually command a radius of 125 miles. In several cases this is extended to 310, 435 or even greater distances. Germany's own quota is 36, mostly located on the coasts of the Baltic and North Seas. It includes the great experimental station at Nauen, which commands a radius of 1860 miles. In the United States are 20 stations, including Fire Island, Washington, New Orleans, San Francisco and San Juan, P. R. Russia has 17 stations. That of Vladivostok is the most important, commanding a range of 620

miles. Austria-Hungary has 10 stations; Denmark and Spain, each 7; Holland, 6 (that of Scheveningen reaches 435 miles); Norway and Sweden, each 5, etc.

"In non-European lands the system has 4 stations in Argentina, 6 in Brazil, 5 in China, 8 in Cuba (that of Havana commanding 930 miles), 6 in Mexico, 2 in the Philippines, 1 in the Sandwich Islands (at Honolulu). The majority of these land stations are government property and under the control of the postal, naval or lighthouse service.

"Most of the installations are on ocean vessels. Of these 22 are on Dutch and German steamers, while 389 are on warships. They include vessels of the following nationalities: German, 140; Russian, 126; American, 43; Swedish, 19; Austrian, 17; Dutch, 10; Norwegian, 8; Argentinian, 6; Danish, 5; Brazilian, 5; Spanish, 5; Greek, 3, and Indian, 2.

"Fifty-four mobile military stations have been installed in several countries, more particularly in Germany, 14; in America, 8; in China, 5; in England, 4; and in Austria-Hungary, 4.—*Electrical World.*

WIRELESS TO ALASKA.—Arrangements have been completed whereby the War and Navy Departments will co-operate in the maintenance of wireless communication between Nome and St. Michael, Alaska, and Seattle and San Francisco. The signal corps of the army now has wireless stations at the Alaskan cities, and next year will establish one at Fort Gibbon, which will be capable of communicating with a naval wireless station to be erected at Valdez. The navy already has several stations in Alaska.

The steel towers which the signal corps is to erect at Fairbanks and Circle, Alaska, to carry wireless telegraph instruments, will be 175 feet high. The distance between the two places is 140 miles, and regular wireless communication is to be maintained.—*Electrical Review.*

NOTES ON TUNING IN WIRELESS TELEGRAPHY. By Sir Oliver Lodge.—The principles of tuning were clearly explained by Mr. Duddell recently; and I shall assume them known; but it is not to be supposed that the application of these principles requires the arc. Sufficient tuning for all practical purposes can be obtained by using the right kind of spark. It is possible to acquire too long a train of waves, in which case the latter half of the train will undo what the former half has begun, in analogy with beats. Thirty or forty swings can be easily got by a spark, and that is enough for practical requirements.

Kind of Spark.—A non-tuned station puts all the energy into a single snap, so as to produce a single discontinuous pulse calculated to affect every kind of station within the range of its power. For a tuned station this sudden snappy spark is to be avoided. The ideal arrangement is a spark of a sufficient number of alternations of approximately equal strength, no one of which is sufficient to operate, but such that the accumulated influence of all of them is powerful. Instead, therefore, of the clean polished metal knobs in fresh or compressed air, which are suitable for a snappy spark, a tuned station may employ a series of points enclosed in ionised air, so as to maintain conduction as long as possible. The maintenance is also assisted by using an alternator with a curve of the right shape—not a sine curve, but a high-shouldered curve (see Fig. 1)—so as to keep up the stimulating potential for a sufficient time. The spark passes when the potential corresponds to the point *a*, and a number of oscillations of nearly equal intensity are made between *a* and *b*. It is this kind of spark which at the Lodge-Muirhead station at Elmers End was photographed by Mr. Duddell on a revolving mirror, and exhibited on Friday night.

Effect of the Earth.—But attention to the spark alone is not sufficient; it is necessary to eliminate the influence of the earth. For the snappy or non-tuned emission, such as was employed by Mr. Marconi for great distances, it is convenient to use an elevated wire on the one hand, and the earth on the other; but for a tuned station this is not appropriate. A tuned

station requires two capacity areas above the earth, as published by me in 1897. These capacity areas are usually horizontal frames (see Fig. 2) of shapes devised by my friend and partner, Dr. Alexander Muirhead, who has found that there is a best position for the lower ærial, such that the capacity is a minimum. It was under these circumstances that the photograph above spoken of was taken, and the sending efficiency is most marked. If the lower ærial be too much raised, the radiating power is diminished; if it be lowered, the train of waves is shortened, until when it is allowed to touch the earth—still more of it is connected with the earth—there is hardly any train of waves at all, and the discharge is almost dead-beat.

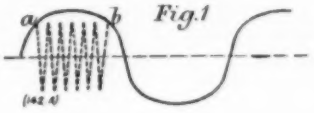


Fig. 1

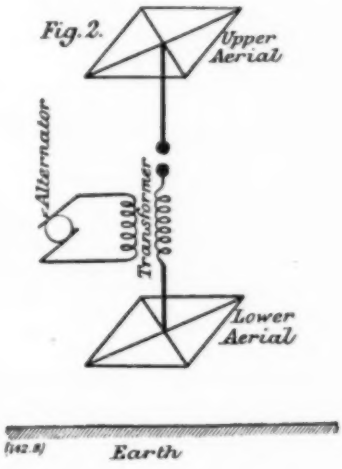


Fig. 2.

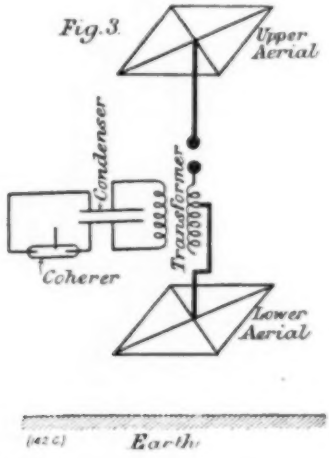
There is a great advantage in the getting rid of earth contacts, inasmuch as variations of moisture and uncertainties of the soil do not enter in to confuse the problem and throw the tuning out. But even if the earth remained constant, it would be deleterious; it seems by its resistance to damp out the vibrations and shorten the train of waves, in so far as it is allowed to exert any influence.

Method of Receiving from a Distant Tuned Station.—The first thing is to tune up accurately the receiver. This can be done by a Duddell radiomicrometer, which measures the received energy satisfactorily, although it is very small. Tuning is altered until the reading on this micrometer rises to a high value, then the receiving apparatus is purposely made unsensitive, so that the coherer will only respond to this high value; in other words, to the top of the curve. The message can then be received from the desired station. If the receiving apparatus were left sensitive, it would be affected violently by the desired station, but it would pick up a number of disturbances from other stations. By working at the top of the curve, it feels the desired station alone.

Perfection of Tuning.—In this way it was possible to receive at Hythe from Elmers End, whilst a much more powerful and nearer station at Dover was making a disturbance, which was entirely eliminated. It is easy to hear the ships in the Channel, but it is also easy to tune everything out, and listen to the desired station alone. A 5 per cent change could be made to throw this out and throw a neighboring one in; but in practice it would be undesirable to try to work quite so close as that. With changes of that order of magnitude, however, several neighboring sending stations can be made to send to several neighboring receiving stations without interference. That is to say, diplex telegraphy is possible, though not duplex.

Tuning at the Sending End.—In order to economize power, it is desirable to have every part tuned. The ærials connected through the secondary of a peculiarly made Ruhmkorff coil constitute one oscillating system of a low frequency, to correspond with an ordinary commercial alternator which excites them. When the swing is worked up, they burst through the spark-gap, short-circuiting out the Ruhmkorff, and giving excessively

Fig. 3.



(42 C)

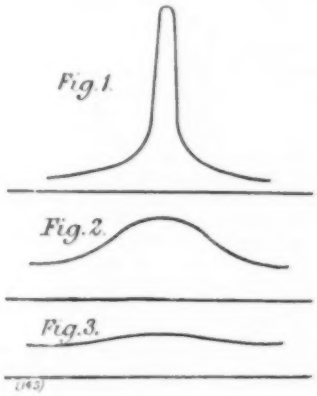
rapid oscillations, which are the ones transmitted. These are picked up by the receiving station, and transferred at constant frequency into a closed condenser-circuit (see Fig. 3), which, when its swings reach a maximum overflow into the coherer. This is called the "overflow method," and was described by me in 1889 and 1891.

Ratio of Received to Emitted Energy.—Theoretical calculations show that the energy received, compared with the energy radiated, depends on the cube of the linear dimensions of emitter and receiver, if they are alike, and likewise on the cube of the distance between them. Measurements made with the radio-micrometer confirm this estimate approximately, the value in one series of experiments being 10^{-9}. Although this is a small fraction, the accuracy of the tuning is such that messages are sent between Burma and the Andaman Island—a distance of about 300 miles—with less than a horsepower.

Other Precautions.—To get such a result, precautions must be taken to avoid damping out the oscillations, not only by elevation of the lower ærial above the earth, but by using appropriate condensers for these excessively high frequencies. To this end the wires used are finely subdivided in insulated strands, and consist of a great cable or bundle of thinly-insulated No. 40 wires, and the various self-inductions, and other arrangements for

effecting tuning, are similarly wound. The tuning capacities are also arranged so as to be continuously adjustable without pegs or discontinuities, and every kind of broken or uncertain contact is scrupulously avoided.

In the discussion of the foregoing paper, Sir Oliver Lodge made the further remarks which follow. He was not surprised at the incredulity expressed as to the advantage gained by cutting off the transmitting and receiving circuits from the earth. The problem was a very curious one, and at first it was thought that a good connection to earth was a great advantage. He still thought that the earth, or rather the sea and the sky, had an important effect in facilitating long-distance transmission by means of a kind of reflection. The electro-magnetic waves were apparently confined within two reflecting shells constituted by the upper layers of the atmosphere, which were, it was well known, good conductors, and the lower conducting shell constituted by the sea. The reflection of the waves from these two conducting shells helped the radiation to follow the curvature of the earth round to surprising distances.



If, however, the earth were coupled up to the lower element of his transmitter, the train of waves was damped out; and if, on the other hand, the distance between the upper and lower elements was too much diminished, an insufficient number of lines of force escaped to work the distant apparatus. There was, therefore, as already stated, a best elevation for the lower ærial. The lines of force between the latter and the earth, to which Sir William Preece had referred, existed, but did not prolong the oscillation, which was what was wanted, and the fewer there were of them the better. This was clearly shown by determining the resonance curves by the Duddell radio-micrometer. With the lower ærial in its proper position the resonance curve was very steep, as on Fig. 1; whilst with it close to the earth, the curve had the form indicated in Fig. 2. Here, it is true, there was a little more energy all the way along the curve, and for non-tuned work this would be an advantage. When, finally, the lower ærial was in actual contact with the earth, the curve obtained was of the character shown in Fig. 3, where there was hardly any resonance at all. This would be all right if your object were to hear every ship within range, but not when it was desired to speak to some particular one. In that case, by arranging matters so that the steep resonance curve was obtained, all the other transmitters could be tuned out.

Professor Trouton here asked if the increased velocity of the waves in the upper regions of the air, where the specific inductive capacity was less, would not also help the waves to follow the curve of the earth. An effect

of this kind must exist, and he wished to know if it was of sensible importance.

Sir Oliver Lodge, continuing, said that Professor Trouton suggested that refraction, as well as reflection, might aid in bending round the electro-magnetic waves to the curvature of the earth; but he thought himself that the whole inductive action was so small that there would be no practical effect of the kind supposed. The suggestion he had made as to the sea and sky acting as reflectors was, however, he wished to say, at present a mere hypothesis, and wanted further investigation. In reply to a question from Mr. Hawksley, he added that the elevation of the ærials was settled once for all, and any further tuning required was made by adjustments of capacity and self-induction within the station. After a little practice, corporals or sergeants of the Royal Engineers could pick up the note of any sending station in one or two minutes; whilst, of course, if they already knew this note, they could adjust the receiver for it instantly.—*Engineering.*

MISCELLANEOUS.

BRITISH AND FOREIGN NAVIES.—The annual return showing the fleets of Great Britain, France, Russia, Germany, Italy, the United States of America, and Japan, on March 31, 1907, has been issued. All vessels which still retain their armaments, and are not for sale, are included. The vessels are shown in 12 classes, and those built are shown separately from those building, while vessels are not transferred from the "Building" to the "Built" section until they have completed their trials and are ready for commissioning. In each class vessels are arranged in types, the latest designed type being placed first in the case of those built, and last in the case of those building. A nominal statement prefaces each class and shows in a convenient form the strengths of the various Powers. From these statements we obtain the following figures and footnotes:

Built.

	Great Britain.	France.	Russia.	Germany.	Italy.	United States.	Japan.
Battleships	60	31	10	32	15	23	15
Coast Defence Vessels	—	8	2	11	—	11	1
Cruisers:							
Armored	30	18	3	6	6	12	10
Protected, 1st class	21	7	7	—	—	3	2
" 2d class	45	12	2	16	4	16	11
" 3d class	16	16	1	12	13	2	8
Unprotected	—	1	2	15	—	5	3
Scouts	8	—	—	—	—	—	—
Torpedo Vessels	20	14	7	1	9	2	1
Torpedo-boat Destroyers	143	34	85	47	17	20	56
Torpedo-boats	89	280	162	84	108	32	79
Submarines	37	40	20	1	4	8	7

Notes.—France: One battleship badly damaged and one probably to be condemned. Six of the coast defence vessels are armored gun vessels. One 1st class and two 3d class protected cruisers expected to be condemned.

Russia: The coast defence vessels are armored gun vessels. One 2d class protected cruiser is partially protected. The unprotected cruisers are training ships. All information as to submarines is very doubtful.

Germany: The coast defence vessels are armored gun vessels. Six unprotected cruisers are training ships. One t. b. d. sank, but raised May, 1906, and may be repaired.

Italy: Two 3d class protected cruisers are partially protected.
United States: One coast defence vessel is for ramming only.

Building.

	Great Britain.	France.	Russia.	Germany.	Italy.	United States.	Japan.
Battleships	5	10	4	8	5	7	2
Coast Defence Vessels	—	—	—	—	—	—	—
Cruisers:							
Armored	8	5	4	4	4	3	3
Protected, 1st class	—	—	—	—	—	—	—
" 2d class	—	—	—	8	—	—	1
" 3d class	—	—	—	—	—	—	—
Unprotected	—	—	—	—	—	—	2
Scouts	—	—	—	—	—	3	—
Torpedo Vessels	—	—	—	—	—	—	—
Torpedo-boat Destroyers	8	31	12	26	—	5	—
Torpedo-boats	17	19	—	—	5	—	—
Submarines	11	59	8	2	2	4	—

Notes.—France: Six battleships ordered to be laid down in 1906; work on these has been commenced, but it is uncertain if all the keels have been actually laid. Two t. b. d.'s are armored; six are ordered to be laid down, but it is uncertain whether they are actually commenced; and five are to be laid down in 1907. Twenty submarines ordered to be laid down, but it is uncertain whether they are actually commenced; 10 to be laid down in 1907.

Russia: All information as to submarines is doubtful.

Germany: One battleship of program 1906-7, to be laid down April, 1907; two battleships of 1907-8 program. One armored cruiser to be laid down 1907-8. Two 2d class protected cruisers to be laid down 1907-8. Twelve t. b. d.'s to be laid down 1907-8. One submarine to be laid down in 1907; £73,385 allowed for submarines in estimates, 1905-6, £122,309 in 1906-7, and £146,771 asked for in 1907-8.

Italy: One battleship of 1907-8 program.

United States: Two battleships not yet laid down, one of 1906-7 program and one of 1907-8 program. The five t. b. d.'s not yet laid down (three of 1906-7 program, two of 1907-8 program). £205,486 allowed for submarines in estimates, 1906-7 and 1907-8.—*Army and Navy Gazette.*

In the course of a speech in the House of Lords, the First Lord of the Admiralty gave a classification of the recent Dilke Return, showing the real comparative strength of Great Britain and the other Powers in completed first-class battleships less than 25 years old, and armored cruisers less than 20 years old, thus ruling out a number of old and useless men-of-war. Lord Tweedmouth, at the same time, indicated that in the opinion of the Admiralty, certain of the ships remaining after applying this test of age might be regarded as obsolescent, and therefore of slight fighting value. At the suggestion of Lord Cawdor, the late First Lord, this statement has been issued as a parliamentary paper. The following are the totals for each of the Powers:

Battleships.

	Efficient.	Obsolescent.	Total.
Great Britain	39	18	57
France	14	6	20
Germany	11	9	20
Japan	9	2	11
United States	18	4	22

Armored Cruisers.

Great Britain	32	—	32
France	18	—	18
Germany	6	—	6
Japan	10	—	10
United States	12	—	12

Included in the French battleships in the second column is the *Iéna*, which was badly damaged by explosion and fire recently.—*United Service Gazette.*

THE WORLD'S WARSHIPS.—Among warships built or under construction on July 1, 1907, no less than 49 are of 16,000 tons displacement or upward and 137 others of upward of 12,000 tons. This compares with a total of 139 upward of 12,000 tons in 1903 and only 77 in 1899. Of the largest size, England possesses the greatest number, with 17, followed by the United States with 10, France and Japan with 6 each and Germany with 5. Of those between 12,000 and 16,000 tons, England has a still greater lead, with 58 against 20 for the United States, 15 for France, 12 each for Italy and Japan, 11 for Germany and 9 for Russia.

Comparisons of Speed.—When it comes to a question of speed—excluding all forms of torpedo craft—we find that the total number capable of 24 knots or higher on July 1, 1907, was 24, with 111 others from 22 to 24 knots and 163 more from 20 to 22 knots. This makes a total of 298 of 20 knots or more, compared with 256 in 1903 and 179 in 1899. The advance is most marked among the vessels of the highest speeds, the total above 22 knots being 135 at present, as compared with 92 in 1903 and only 38 in 1899. With her immense navy to draw from, England leads in number of swift vessels, as well as in large ones. She has 14 ships of 24 knots or more, 32 of 22 knots and 50 of 20 knots. The United States has 3 of 24 knots, 15 of 22 and 10 of 20 knots. Germany has, respectively, 2, 19 and 16. Japan has 1, 8, and 18. Italy has 1, 6, and 11. No other large power has ships of over 24 knots. France has 11 of 22 knots and 26 of 20 knots. Russia has 7 of 22 knots and only 4 between 20 and 22 knots.

Considering the speeds of all the navies, minor as well as major, and omitting all torpedo craft, the premier position is held by Chile, with 20.74 knots, England being second with 20.14 knots. The others in order are Brazil, 19.7 knots; Japan, 19.65 knots; Italy, 19.47 knots; Austria, 19.22 knots; France, 18.94 knots; United States, 18.9 knots; Germany, 18.76 knots; China, 18.66 knots; Argentina, 18.61 knots, and Russia, 18.06 knots. The inclusion of so many of the smaller naval powers high up in this list is due in very large measure to the fact that most of them possess fleets made up largely of cruisers, which are naturally of greater speed than the heavy battleships of the greater powers.

Comparisons of Total Tonnage.—Excluding torpedo craft and obsolete and worn out vessels, the navies of the world included, on July 1, 1907, in vessels built and building, 963 ships of a total displacement of 6,099,448 tons, or an average of 6332. The total number of guns of primary and secondary batteries, including torpedo tubes, was 29,527, or an average of about 31 per ship. The average speed of the ships was 18.94 knots.

Greater Britain, as usual, accounts for the largest force, with 197 ships of 1,841,730 tons, or an average of 9349. The average speed of these ships is 20.14 knots. The total number of guns is 7403, or an average of 38 per ship. France comes second, with 112 ships of 812,345 tons, or an average of 7231. The speed averages 18.94 knots. There are 3488 guns, or an average of 31. The third place is held by the United States, with 110 ships, of 799,028 tons, or an average of 7264. The average speed of the American ships is 18.9 knots. The guns number 3924, or an average of 36. Germany has 120 ships, aggregating 707,870 tons, or an average of 5899, with

an average speed of 18.76 knots and a total battery of 3811 guns, or an average of 32.

No other power has as much as 500,000 tons in the navy, Japan coming closest to this mark, with 63 ships and 486,872 tons, or an average of 7728, and an average speed of 19.65 knots. The guns number 2267, or an average of 36. Russia and Italy are close rivals in tonnage. Russia has 56 ships, of 358,296 tons, or an average of 6398 and a speed of 18.06 knots. They carry 1854 guns, or an average of 33. Italy has 57 ships, of 357,491 tons, or an average of 6272, and a speed of 19.47 knots. The guns number 1976, or an average of 35. The only other navy of real importance is that of Austria, which includes 29 ships, of 128,865 tons, or an average of 4444, and a speed of 19.22 knots. The guns number 770, or an average of 27 per ship.

The Anglo-Saxons are thus seen to possess 307 ships, of 2,640,758 tons, or an average of 8602, with a mean speed of 19.77 knots and a total battery of 11,327 guns, or an average of 37. This is ahead of any conceivable outside political combination, for France, Germany, Russia, Italy, Austria, and Spain combined have but 396 ships, of 2,430,696 tons, or an average of 6412, and a mean speed of 18.81 knots. Their guns number 12,319, or an average of 31.—*Iron Age.*

SHIPBUILDING ESTIMATES OF THE WORLD.—The Admiralty state that the total sums set down in the navy estimates, 1907-8, of Great Britain, France, Germany, and the United States for shipbuilding, repairs, and armaments, "on the same basis as the answer given on November 13, 1906," to Mr. Bellairs, are as follows:

Great Britain.

	1907-8 Estimate.
Shipbuilding	£8,113,202
Repairs and maintenance of material (*i. e.*, hulls, machinery, and equipment, anchors, cables, etc.), but not stores	1,800,198
Armament and first outfit of ammunition for new ships and re-armed ships	1,127,000
Repairs and maintenance of guns and torpedoes	62,000
Total	£11,102,400

France, Germany, and United States.

Aggregate sums voted for shipbuilding, repairs, and armaments:

Country.	Financial Year.	Estimates.
France	January to December, 1907	£5,724,468
Germany	April, 1907, to March, 1908	7,287,025
United States	July, 1907, to June, 1908	9,387,072 [1]
Total aggregate		£22,398,565

[1] This figure includes a sum of £821,946 towards the accumulation of a reserve supply of ammunition.—*United Service Institution.*

HIGH SPEED IN THE BRITISH NAVY.—At the concluding meeting of the Conference of the Institution of Civil Engineers, at Westminster, Professor J. J. Welch dealt with the subject of "High-speed Vessels," confining his attention mainly to those designed for the British Navy.

He pointed out that the maximum speeds on trials had been practically doubled within the past 30 years, and that though none of the 33-knot destroyer type had yet been tried, and the *Swift* was still building, it was confidently expected that their designed speeds with heavy loads on trial would be realized. Side by side with this development of speed, the sea-

going and sea-keeping qualities of the vessels had been greatly augmented, the length of torpedo-boats having grown from the 89 feet of the *Lightning* to the 185 feet of the most recent of the type, while the dimensions of destroyers had increased from 185 feet to 345 feet. It was, of course, essential in high-speed vessels to save weight wherever practicable. The *Turbinia*, a special vessel 100 feet long and displacing 44½ tons on trial, marked with her rotary engines a notable advance, no less than 72 horsepower being estimated to be produced per ton of machinery. Necessarily this standard was not reached in the larger vessels of the seagoing destroyer type subsequently built and fitted with turbine machinery, but the results were distinctly in advance of those obtainable with reciprocating engines, while a still better performance might be reckoned upon in the latest vessels provided with turbines and with boilers using oil fuel. Even from the point of view of comfort, the introduction of oil fuel had secured important advantages, the operation of fuelling the ship and furnaces was less laborious and more cleanly than before, while the hot cinders which frequently fell during a full-speed trial on the deck of a destroyer using coal, were in the latest vessels conspicuous by their absence. With regard to the future, much was hoped for from the attention now being directed to the development of internal combustion motors using gas or oil. From particulars in his possession of a gasoline motor recently built abroad for marine work, it appeared that such apparatus would produce power equivalent to 600 i. h. p. per ton. Experiments with comparatively small vessels would doubtless point the way to improvements in larger types, and as the result they might expect that, just as the high performance of the special vessel *Lightning* as regarded horsepower produced per ton of machinery was ultimately reproduced in much larger and heavier seagoing vessels, so in due time it would be possible to attain in such vessels the very high standard set by the special vessel *Turbinia*.—*United Service Gazette.*

BOOK NOTICES

"The Campaign of Santiago de Cuba." By H. H. Sargent, U. S. Army. A. C. McClurg & Co., Chicago. 3 vols. $5.00

Immediately after the Spanish War there came upon us a deluge of books describing that struggle. The American public wished to know it all and publishers gratified that wish as best they could. Many of these were interesting but all had the defect of being written too soon after the war was over, and most of them were written too hurriedly to be of permanent value.

The Naval Institute has recently received a work in three volumes, "The Campaign of Santiago de Cuba," by Captain H. H. Sargent, U. S. Army, the intrinsic excellence and importance of which entitles it to a more elaborate review than the Naval Institute is able to give to it. This work is well worthy of special attention from "M. W. H.," of the New York Sun.

Captain Sargent spent between five and six years in writing these volumes. He was well prepared for the task. He is an officer of experience, a West Point graduate; he had commanded a regiment in Cuba, and later another regiment in the Philippines. For years he had been a student of grand tactics, and had published important works on Napoleon's Campaigns.

This work is divided into fifteen chapters, as follows: I. The Cuban Insurrection. II. The Declaration of War. III. The Theatres of Operations. IV. The Two Navies. V. The Situation of the Naval Forces and the Outlook from a Strategical Point of View. VI. The Resources, the Armies, and the Coast Defenses. VII. The Situation of the Military Forces, the Plans of Campaigns, and the Outlook from a Strategical Point of View. VIII. The Blockade of Havana and the Early Naval Operations. IX. The Blockade of Santiago Harbor. X. The Sailing and the Disembarkation of the Fifth Corps. XI. Las Guasimas. XII. El Caney and San Juan. XIII. The Destruction of Cervera's Squadron. XIV. The Siege and the Capitulation of Santiago de Cuba, and the Re-embarkation of the Fifth Corps. XV. General Comments. Recent Changes in the Military Art—The Fortune of War—The Military Policy of the United States. The Navy. The Army. Appendices. Index.

A novel feature of this work is that the purely historical features of each chapter are followed, under the heading of "Comments," by remarks in the nature of an essay, generally suggested by the recountal of the historic facts. For instance, in the first chapter Captain Sargent gives a succinct, though sufficient, account of the Cuban insurrections of 1868, and of 1895. Under "Comments," he tells us why 196,000 Spanish troops could not crush 25,000 insurgents. He says: "First: The cordon

system of making war which was adopted by the Spaniards was faulty. The Spanish army was greatly weakened in strength and fighting power by being scattered, and by attempting to occupy and hold a line entirely across the island. . . . This system is directly opposed to the true system—that of concentration. . . .

"Secondly: The Spaniards followed the defensive method of warfare. Having built their *trochas*, they occupied them and awaited developments. . . . They should have taken the field against the insurgents; sought for them everywhere; followed them when found; attacked, routed, annihilated, or driven them into the sea. . . .

"Thirdly: The cavalry of the Spaniards was too small. . . ."

In the same way, in every chapter, Captain Sargent first gives the history, then comments of his own on the strategy and tactics of the opposing commanders, the plan of campaign and methods of operation. He boldly criticizes the naval and military chiefs; this would be fatal from the pen of any but an expert. But here is where Captain Sargent is strong. He has had actual practice in the field, and he is evidently familiar with all great military operations. The history and comments on the naval features of the campaign occupy a large portion of this work. It is evident that before he began to write he had been a deep student of Captain Mahan; he witnessed naval operations, studied them, and applied the principles as enunciated by Mahan, and believed in by himself to West Indian conditions. In "Comments" on principles of naval warfare, Captain Sargent says:

"All results in warfare are produced by the application of force, and the indispensable requisite for success is to be superior to the enemy at the point of contact in numbers, weapons, or position. The purpose of the science of war is to effect this superiority, which can be obtained only by concentration of forces. To concentrate one's forces and thus be superior to the enemy on the battle field is the correct system on land or sea for winning victories. This system, confined to no element, limited to no time, applicable everywhere and forever, is the foundation of all successful military operations." This is surely talk of the right sort. In Captain Sargent's work it is clear what part is history, and what is his personal criticism.

For his materials Captain Sargent went to the original sources. His history is clearly written; in short, concise, forcible sentences; he has such a happy way of presenting facts that he never is dull or tiresome. He received statistics from the Spanish government as to the numbers of Spanish soldiers at Santiago. The surprising fact is developed that at all times our American army was far inferior in numbers to the Spaniards about Santiago.

In his comments the author criticizes Admiral Sampson's plan for an attack of Havana, and for the trip to San Juan. He praises most highly his conduct of operations about Santiago. He believes the idea of bottling up the ships at Santiago by the Merrimac was good strategy—there was apparently great need of ships just then, the purpose was to release ships blockading Santiago.

For that part of his work which is history we tender Captain Sargent our most sincere appreciation. We are generally in accord with his comments, and commend his naval strategy. At the same time in his comments he makes statements which are not history, and could easily be combatted. For instance, he says the Spaniards are "an extraordinarily brave people." They undoubtedly are a brave, a devoted people. But is it conceivable that with torpedo boats, an "extraordinarily brave people" would have allowed months to go by without ever making a dash at the blockading ships off Santiago or Manila?

Captain Sargent goes to some length to show that at the beginning the opposing navies were not unevenly matched. Every practical naval officer knows we were superior from every point of view.

Again, Admiral Cervera is referred to as a great man. His was certainly a noble soul, but no act of his ever stamped him as a great man. He was soundly whipped before he ever started for the West Indies. Santiago is stated to be the greatest sea fight America ever engaged in. That is open to argument.

Some of Captain Sargent's comments are futile, as where he points out mistakes in conceptions of strategy by Admiral Sampson. Futile because he knows now all sorts of things that Admiral Sampson could not have known. Existing conditions determine the moves of the war game.

The last chapter is at once the best and the worst. The worst because it wanders from the subject. The best because of the keen ideas on military and naval matters there displayed.

An appendix is included which gives much knowledge to students of this campaign. And there is also a complete index of the three volumes.

On the whole it must be agreed that the work of Captain Sargent on the Campaign of Santiago is by far the best that has yet appeared. It is bound to appeal to naval officers, because it is written in complete appreciation of the navy's part in that campaign, and it is perfectly evident that the writer can discuss naval strategy and naval warfare with any one.

Naval officers are not book worms, but are great readers. It is to be hoped that the Navy Department will have copies of this work sent to all of our warship libraries, and it is quite certain that Captain Sargent's excellent volumes will be widely read by naval officers throughout the service.

E. L. BEACH,
Lieut.-Comdr., U. S. Navy.

"Leading American Soldiers." The notable interest in American biography has generally been met by two widely different classes of publications—the biographical dictionaries, and volumes devoted each to an individual.

There is room for a series combining the merits of both, devoted to individuals in whose lives everybody is interested, and systematically arranged.

Such a one, to be called "Leading Americans," is now being prepared

under the editorship of W. P. Trent. It will include only those (not living) whose names are known to virtually all reading people, and will be written by the most capable authors who can be interested in the task. Pains will be taken to make the volumes interesting and inspiring no less than reliable and instructive.

The series will consist of large 12mo volumes, each containing from half a dozen to a score of biographies, classified by volumes according to the pursuits of the men treated.

The first of this series, "Leading American Soldiers," by R. M. Johnston, Lecturer in Harvard University, has just appeared. It contains lives of Washington, Greene, Taylor, Scott, Andrew Jackson, Grant, Sherman, Sheridan, McClellan, Meade, Lee, "Stonewall" Jackson, and Joseph E. Johnston. These men are remembered chiefly as soldiers, and as soldiers they are here presented. Their principal battles are treated in considerable detail, which makes the book, as a whole, a composite military history from the interesting view-point of the dominant personalities. The presentation of tactics is lucid and anecdotes that indicate personality as effectively as historical performances are frequent. While written with a view to the general reader, this book is not on a plane which will make it incomprehensible to any boy of fifteen.

(Published by Henry Holt and Company. Price $1.75 net; $1.90 by mail.)

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NOTICE.

The U. S. Naval Institute was established in 1873, having for its object the advancement of professional and scientific knowledge in the Navy. It now enters upon its thirty-fourth year of existence, trusting as heretofore for its support to the officers and friends of the Navy. The members of the Board of Control cordially invite the co-operation and aid of their brother officers and others interested in the Navy, in furtherance of the aims of the Institute, by the contribution of papers and communications upon subjects of interest to the naval profession, as well as by personal support and influence.

On the subject of membership the Constitution reads as follows:

ARTICLE VII.

Sec. 1. The Institute shall consist of regular, life, honorary, and associate members.

Sec. 2. Officers of the Navy, Marine Corps, and all civil officers attached to the Naval Service, shall be entitled to become regular or life members, without ballot, on payment of dues or fee to the Secretary and Treasurer. Members who resign from the Navy subsequent to joining the Institute will be regarded as belonging to the class described in this Section.

Sec. 3. The Prize Essayist of each year shall be a life member without payment of fee.

Sec. 4. Honorary members shall be selected from distinguished Naval and Military Officers, and from eminent men of learning in civil life. The Secretary of the Navy shall be, *ex officio*, an honorary member. Their number shall not exceed thirty (30). Nominations for honorary members must be favorably reported by the Board of Control, and a vote equal to one-half the number of regular and life members, given by proxy or presence, shall be cast, a majority electing.

Sec. 5. Associate members shall be elected from Officers of the Army, Revenue Cutter Service, foreign officers of the Naval and Military professions, and from persons in civil life who may be interested in the purposes of the Institute.

Sec. 6. Those entitled to become associate members may be elected life members, provided that the number not officially connected with the Navy and Marine Corps shall not at any time exceed one hundred (100).

Sec. 7. Associate members and life members, other than those entitled to regular membership, shall be elected as follows: "Nominations shall be made in writing to the Secretary and Treasurer, with the name of the member making them, and such nominations shall be submitted to the Board of Control, and, if their report be favorable, the Secretary and Treasurer shall make known the result at the next meeting of the Institute, and a vote shall then be taken, a majority of votes cast by members present electing."

The Proceedings are published quarterly, and may be obtained by non-members upon application to the Secretary and Treasurer at Annapolis, Md. Inventors of articles connected with the naval profession will be afforded an opportunity of exhibiting and explaining their inventions. A description of such inventions as may be deemed by the Board of Control of use to the service will be published in the Proceedings.

Single copies of the Proceedings, $1.00. Back numbers and complete sets can be obtained by applying to the Secretary and Treasurer, Annapolis, Md.

Annual subscriptions for non-members, $3.50. Annual dues for members and associate members, $3.00. Life members fee, $30.00.

All letters should be addressed U. S. Naval Institute, Annapolis, Md., and all checks, drafts, and money orders should be made payable to the same.

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SPECIAL NOTICE.

NAVAL INSTITUTE PRIZE ESSAY, 1908.

A prize of two hundred dollars, with a gold medal, and a life-membership in the Institute, is offered by the Naval Institute for the best essay presented on any subject pertaining to the naval profession, subject to the following rules:

1. The award for the prize shall be made by the Board of Control, voting by ballot and without knowledge of the names of the competitors.

2. Each competitor to send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1908. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Board.

3. The successful essay to be published in the Proceedings of the Institute; and the essays of other competitors, receiving honorable mention, to be published also, at the discretion of the Board of Control; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Board.

4. If, in the opinion of the Board of Control, the best essay presented is not of sufficient merit to be awarded the prize, it may receive "Honorable Mention" or such other distinction as the Board may decide.

5. In case one or more essays receive "Honorable Mention," the writer of the first of them in order of merit will receive seventy-five dollars and a life-membership in the Institute.

6. Any essay not having received honorable mention, may be published also, at the discretion of the Board of Control, but only with the consent of the author.

7. The essay is limited to fifty (50) printed pages of the Proceedings of the Institute.

8. All essays submitted must be either typewritten or copied in a clear and legible hand.

9. In the event of the prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of the gold medal.

By direction of the Board of Control.

PHILIP R. ALGER,
Professor, U. S. N., Secretary and Treasurer.